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DRAFT REPORT
HYDROLOGIC AND GEOCHEMICAL STUDY PROPOSED MESQUITE MINE EXPANSION IMPERIAL COUNTY, CALIFORNIA

September 13, 1999

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On behalf of:

Newmont's Mesquite Mine
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1.0

INTRODUCTION

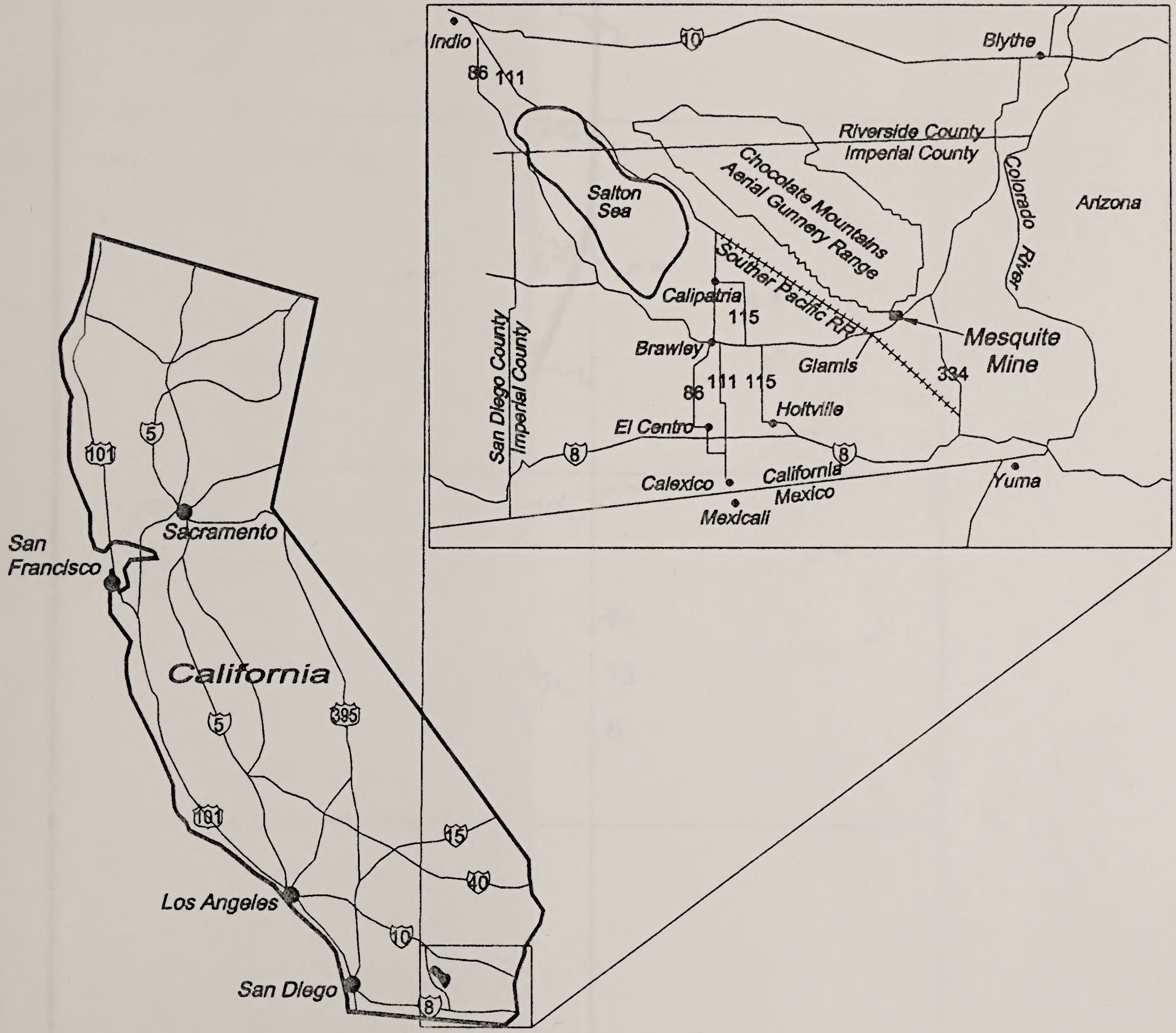
1.1 PROJECT SUMMARY

The Mesquite Mine is located in eastern Imperial County along the southern slope of the Chocolate Mountains in southeastern California (Figure 1-1). The mine site is bounded on the north by the United States Navy Chocolate Mountains Aerial Gunnery Range and on the south and east by State Highway 78. The mine is operated by Newmont Gold Company (NGC), a subsidiary of Newmont Mining Corporation (NMC). The mine has been in operation since late 1985, and consists of three open pits, overburden/interburden storage areas (OISAs), seven heap leach pads and other facilities (Figure 1-2). The three mine pits are: the Big Chief, Vista and Rainbow, with mining currently occurring under existing permits. Past and present operations are described in the Mesquite Mine Consolidated Plan of Operations (POO) (Santa Fe Pacific Gold Corporation (SFPG), 1995). Current reserves will be depleted in the year 2000, but additional reserves have been identified outside of the current project boundary.

The mine has proposed an amendment to the POO to allow expansion of the following existing facilities:

- Extension of the Big Chief Pit;
- Extension of the Rainbow Pit;
- Construction/modification of infrastructure on public land;
- Expansion of heap leach facilities on private land; and
- Expansion of OISAs.

The proposed expansions would allow the mine to continue operating through the year 2006. The details of the proposed expansion are described in the Plan of Operations for the Proposed Mesquite Mine Expansion (Shepherd Miller, Inc. (SMI), 1998c). The proposed expansion is the subject of an Environmental Impact Statement (EIS) and concurrent Environmental Impact Report (EIR). The joint EIS/EIR document is being prepared in cooperation by the US Bureau of Land



Source: Newmont Mining Corporation

Mesquite Mine Expansion
Prepared for
Imperial County Planning and Building Department

Figure 1-1

Vicinity Map

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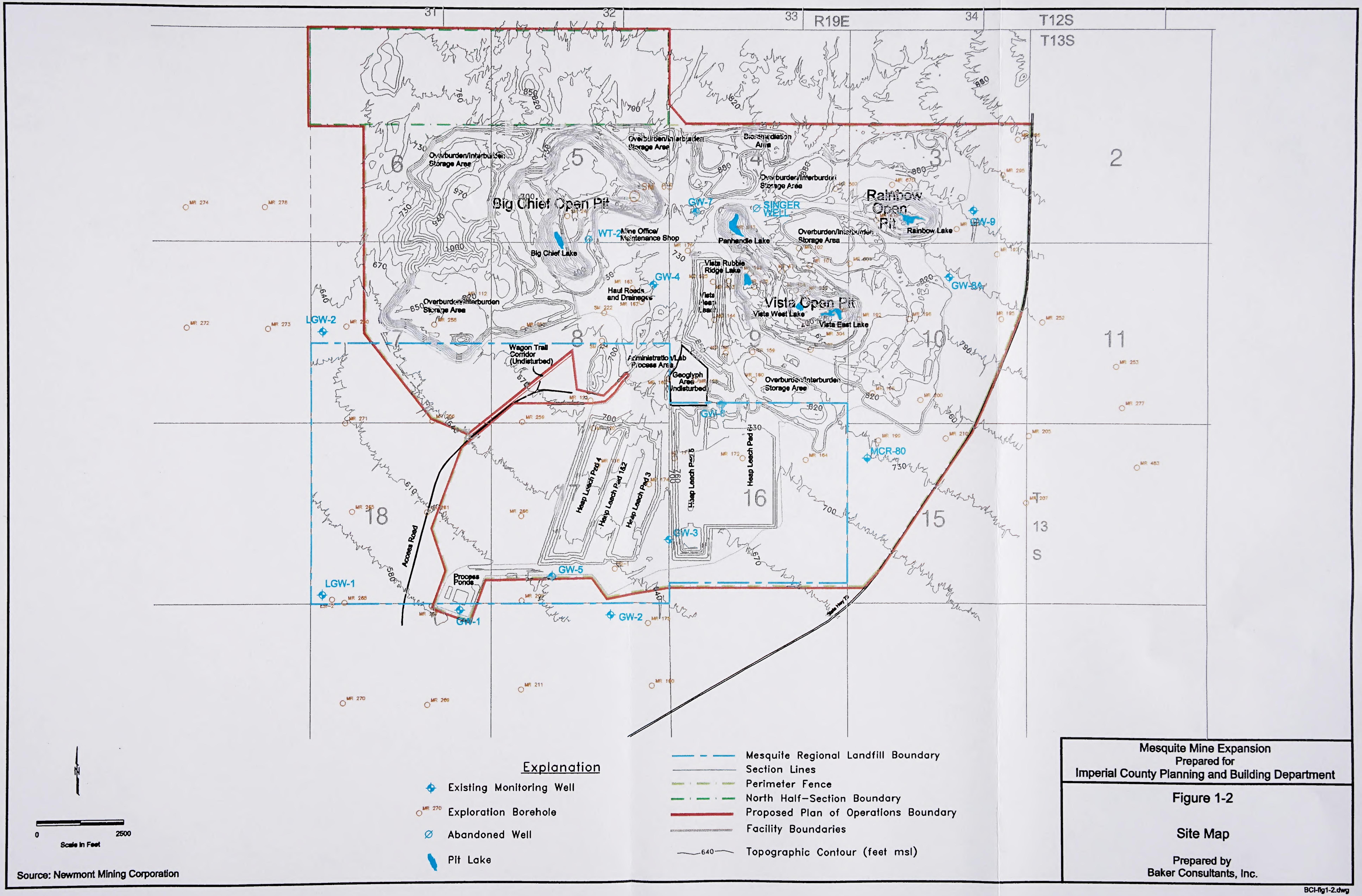

Explanation

- Existing Monitoring Well
- Exploration Borehole
- Abandoned Well
- Pit Lake

- Mesquite Regional Landfill Boundary
- Section Lines
- Perimeter Fence
- North Half-Section Boundary
- Proposed Plan of Operations Boundary
- Facility Boundaries
- Topographic Contour (feet msl)

Mesquite Mine Expansion
Prepared for
Imperial County Planning and Building Department

Figure 1-2

Site Map

Prepared by
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Management (USBLM) and Imperial County. This effort conforms to both the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). Imperial County Planning and Building Department is the lead agency in this combined effort.

1.2 PURPOSE AND SCOPE

Baker Consultants, Inc. (BCI) was retained by Imperial County to conduct a Hydrologic and Geochemical Study of conditions that may exist if the Mesquite Mine expansion is approved. The scope of the study is to:

(1) Summarize existing hydrologic and geochemical/water quality conditions at the mine using available and relevant data;

(2) Develop a conceptual model of the hydrologic system for the portions of the site affected by the proposed expansion;

(3) Evaluate the out-of-pit OISA (open pit) and in-pit OISA (backfilled pit) options with respect to the following elements:

- Dewatering rates during mining,
- Overall site water balance for existing and future conditions,
- Estimate ground water elevations after mining,
- Estimate flux to pit lakes if they are predicted to form and estimate flux through backfilled pits,
- Identify downgradient areas that may potentially be affected by ground water passing through pit backfill and estimate its future water quality, if possible,
- Estimate the final elevation of pit lakes, should they form,
- Estimate the future quality of water within any pit lakes that may form,
- Estimate the potential effects of each option on water resources; and

(4) Prepare a report describing the results from the study.

1.3 DOCUMENT ORGANIZATION

This report is organized into six sections and four Appendices. Section 1.0 provides an introduction to the Hydrologic and Geochemical Study, objectives and a brief description of mine facilities. Section 2.0 summarizes geologic, hydrologic and water quality conditions at the site, including previously-performed determinations of rock acid-base characteristics, whole rock chemistry and results from kinetic tests. Section 3.0 presents the methodology and results from the evaluation of the out-of-pit OISA (open pit) mining option. Section 4.0 provides a similar discussion of the methodology and results for the within-pit OISA (backfilled pit) option. Sections 5.0 and 6.0 provide the conclusions of the study and references cited, respectively. Finally, the Appendices contain tables and summaries of supporting data used in the study.

2.1 GEOLOGY

2.1.1 Regional Setting

The Mesquite Mine is located approximately 40 miles east-southeast of the Salton Sea which occupies the lowest part of the Salton Trough, a major northwest-southeast trending topographic and structural basin within the Basin and Range physiographic province. The Salton Trough is 130 miles long, up to 70 miles wide, and forms the landward extension of the depression filled by the Gulf of California, from which it is separated by the broad, fan-shaped subaerial delta of the Colorado River. The Imperial Valley occupies the southern, wider portion of the Salton Trough, and is bounded by the Salton Sea on the northwest; the Mexicali Valley on the southeast; the Chocolate Mountains on the northeast; and the Peninsular Range of Baja, California on the southwest (Loeltz, 1975). The Salton Trough was formed by crustal spreading between the North American and Pacific tectonic plates along the San Andreas Fault System (Willis and Tosdal, 1992).

2.1.2 Mesquite Mining District Geology

The Mesquite Mining District is located along the south-southwestern piedmont of the Chocolate Mountains, approximately seven miles northeast of Glamis, California (Ferrell et al., 1999). A map of the surficial geology encountered in the vicinity of the mine is presented as Figure 2-1 with the corresponding stratigraphic column included as Figure 2-2 (Ferrell et al., 1999; Willis and Tosdal, 1992; Manske, 1991). Geologic cross-sections oriented southwest to northeast through the Big Chief and Rainbow Pits are presented in Figure 2-3.

The mine lies on the piedmont between the Chocolate Mountains and the northeast margin of the Sand Hills. The Chocolate Mountains are a series of southwestward-tilted fault blocks of exposed Tertiary volcanic rocks. The higher ridges, reaching altitudes of 1,500 feet in the southwest, are capped by flows of basalt and andesite (Olmsted et al., 1973). In some of the

lower parts of the Chocolate Mountains, dissected hills composed of semi-consolidated sedimentary or volcanic rocks of Tertiary age merge on one side with more rugged exposures of hard volcanic or crystalline rocks, and on the other side with more gently dissected exposures of late Tertiary and Quaternary alluvial deposits.

2.1.3 Mine Hydrostratigraphic Units

The hydrostratigraphic units of interest at the mine site consist of materials that are either water-bearing or overlie water-bearing materials and include: alluvium, conglomerate/clay and gneissic basement rock. The alluvial and conglomeratic materials generally contain little ground water based on the drilling of numerous exploration boreholes and hydrologic conditions observed at GW-8A, GW-9, ESI-1 and ESI-2 (Figure 1-2). The first significant water commonly occurs in the gneissic basement rock. A less frequently encountered volcanic unit bearing water was identified in the area of GW-1 located south of Section 18. A nearby borehole (MR-267) suggests that this well may be completed in a basalt or andesite flow.

Quaternary Alluvium

Much of the site is overlain by Quaternary Alluvium consisting of sand and gravel with a clayey to silty matrix. Most authors who have described this unit distinguish between an older and more recent alluvium (Environmental Solutions Inc. (ESI), 1993; ESI, 1987; St. Clair Research Systems, Inc., 1984; Loeltz, 1975). The recent and older alluvium are thought to be as thick as 400 feet in the area of the mine site, and of much greater thickness towards the center of the valley. Uplifted basement rock and erosion in the pit areas have resulted in nearly complete erosion of the alluvium. The more recent alluvial deposits are comprised of sand, silt and gravel. Onsite drilling indicates that the gravel is commonly subangular, poorly sorted, and occurs within a matrix of clay and silt. Cementation is variable across the site and also with depth. The recent alluvium lying along present ephemeral drainages and beneath broad, gently sloping piedmont surfaces lacks the profile development characteristic of the older deposits (Loeltz, 1975). The subangular to angular gravel deposited in a silt and clay

matrix that is described in many boreholes is thought to be representative of such an immature deposit.

The older alluvium is distinguished by a surface of desert varnish (Loeltz et al., 1975). Near the Chocolate Mountains, along the eastern edge of the Imperial Valley, the older alluvium forms a thin blanket and grades into lacustrine silt, sand and clay of the Brawley Formation towards the center of the valley (Loeltz, 1975). The mine site lies in the piedmont area off the southwest face of the Chocolate Mountains. Based on many exploration boreholes drilled at the mine site, the older alluvium in the piedmont area is commonly mapped as gravel with a thickness of as much as 400 feet. The older alluvium is chiefly coarse-grained, of local origin, and generally mantled with thin stream terrace and piedmont deposits (largely gravels) (Loeltz, 1975).

Drillers' logs did not note water production in boreholes drilled through alluvium in the mine area. Ground water was not encountered in the alluvium during drilling at ESI-1 or ESI-2 (ESI, 1993). Alluvium was not logged at GW-8A and GW-9, hence water-bearing alluvium is not thought to be present east of the Rainbow Pit. However, the alluvium becomes an economically important water-bearing unit closer to the center of the Imperial Valley. Approximately four miles south of the mine property, alluvial production wells yield 300 to 800 gallons per minute (gpm) in the wellfield developed for mine use and domestic supply (Fox, 1984; St Clair Research Systems, Inc., 1984; Butler/Roach Group, Inc. (BRG), 1984). The transmissivity of the New Vista Well at the wellfield is 12,000 feet squared per day (ft^2/d) (Fox, 1984).

Tertiary Conglomerate/Clay

A thick Tertiary clay unit is interbedded with a poorly-sorted conglomerate containing a great deal of interstitial clay and silt at GW-8A and GW-9 located east of the Rainbow Pit (SMI, 1997). At GW-8A, the conglomerate/clay unit is 380 feet thick. The same interbedded clay and conglomerate unit is 235 feet thick at GW-9. No overlying alluvium is identified at these

Bear Canyon Conglomerate, appearing lithologically similar to the Tertiary Conglomerate. A Tertiary clay is not distinguished in the landfill area. Loeltz (1975) only identifies a conglomerate in the Chocolate Mountains, and refers to the presence of Tertiary non-marine, coarse sedimentary rocks off the southwest flank of the Chocolate Mountains. The recent geologic interpretation provided by Ferrell et al. (1999), indicates that deposition of poorly sorted conglomerates, fanglomerates, sand and silt occurred following Tertiary deformation of the Chuckwalla and Winterhaven Formations. Given the proximity of GW-8A and GW-9 to the Singer Fault (Figure 2-1), the conglomerate may be such a deposit.

Ground water occurs in the conglomerate and clay units encountered east of the Rainbow Pit (SMI, 1998a), although wells were not completed in these units. The hydraulic conductivity of the conglomerate/clay is reported to be primarily controlled by the degree of cementation and fracturing which is described as variable at GW-8A and GW-9. ESI had previously performed packer testing of unsaturated and poorly to moderately-consolidated conglomerate in the landfill area and obtained values of hydraulic conductivity ranging from 0.002 to 0.02 feet per day (ft/d). Little ground water was detected at borehole ESI-1 in the conglomerate, and no ground water was present in the conglomerate at borehole ESI-2. No significant water from the conglomerate was noted during the drilling of other exploration boreholes.

Quechan Volcanics

The Quechan Volcanics include tuffaceous, rhyolitic and andesitic flows of Tertiary age (Manske, 1991 and Morton, 1966). Outcrops of volcanics are primarily mapped higher in the Chocolate Mountains to the east-northeast of the mine site. A few outcrops of basalt are also mapped west and southwest of the Rainbow Pit (Loeltz, 1975). As mentioned previously, a basalt or andesite is identified at borehole MR-267, located approximately 700 feet west from GW-1. In the absence of a detailed geologic log for GW-1, it is concluded that the well may be completed in a basalt or andesitic lava flow. The results from hydraulic testing conducted by ESI (1993) at this location indicate a much higher permeability (0.18 to 0.58 ft/d) at GW-1 compared to the gneissic bedrock tested at GW-8A and GW-9.

Gneissic Basement Rock

The gneissic basement rock consists of the Chuckwalla Complex, which contains amphibolite to greenschist gneisses, schists and plutonic rocks, and is generally differentiated into biotite gneiss, hornblende gneiss and mafic gneiss (Manske, 1991). In terms of water-bearing properties, all the textural and mineralogical subunits of the gneissic group are considered to represent one hydrostratigraphic unit.

Based on the stratigraphic column shown in Figure 2-2 (Ferrell et al., 1999; Manske, 1991; Morton, 1966), the Chuckwalla Complex may be as thick as 2,200 feet depending upon the thickness of the overlying Bay Horse Quartzite and intrusive granite sills and dikes. The Chuckwalla was thrust over the Orocopia Schist along the Vincent-Chocolate Mountain Thrust (Ferrell et al., 1999). The Chuckwalla and Orocopia sequence has been offset by the high-angle, normal Singer Fault which places the younger Winterhaven Formation in contact with the older, higher metamorphic grade Chuckwalla and Orocopia. The Winterhaven Formation includes phyllites, quartzites, conglomerates and metavolcanics (Ferrell et al., 1999). Deformation of basement rocks, including faulting and folding in the Tertiary and subsequent erosion, resulted in deposition of poorly-sorted conglomerates, fanglomerates, sand and silt as the mantle overlying much of the Mesquite District (Ferrell et al., 1999). A late Miocene basalt flow and recent alluvial gravel deposits cap these units. Regional faulting has offset all of the stratigraphic units with the exception of the recent gravel deposits (Ferrell et al., 1999).

Jurassic, Cretaceous and Mesozoic-aged intrusives are mapped within the pit areas, and intrude the Winterhaven Formation, other Jurassic intrusions and the Chuckwalla Complex. These intrusions include feldspar-rich and biotite-rich granites in the form of dikes, sills and pegmatites. The pegmatites vary in thickness from five to 50 feet; granite thickness ranges from five to 100 feet. A muscovite granite of Cretaceous age is one such unit and is often referred to as a leucogranite, indicating its light-colored nature derived from its mineralogical composition of felsic-rich materials and muscovite. Wells GW-8A and GW-9 east of the Rainbow Pit are completed in fractured mafic gneiss bedrock. The gneiss

is fractured with some gouge, and limonite and hematite coatings along fracture surfaces (SMI, 1997). Near the proposed site for the Mesquite Regional Landfill, at wells ESI-1 and ESI-2, the gneiss is variably fractured and commonly associated with clay development and some gouge (ESI, 1993). Here, the gneiss ranges from competent to friable along foliation.

The hydraulic conductivity of the gneiss is primarily a function of the degree of fracturing, which is variable across the gneissic subunits, and the amount of clay alteration within fractures. ESI estimates of gneiss hydraulic conductivity near the proposed landfill range from 1.4×10^{-4} to 1.0×10^{-3} ft/d (ESI, 1993). SMI estimates of gneiss hydraulic conductivity based on pumping tests conducted east of the Rainbow Pit range from 0.023 to 0.056 ft/d, with a geometric mean value of 0.045 ft/d (SMI, 1998a).

2.2 HYDROLOGIC CONCEPTUAL MODEL

2.2.1 Subregional Scale

The hydrology of the Mesquite Mining District is conceptually similar to other Basin and Range mountain-valley settings. A portion of the precipitation falling at higher elevations along the western slopes of the Chocolate Mountains forms surface runoff to gulleys and arroyos from which it evaporates or is transpired by plants. The remainder eventually infiltrates into soil and serves as recharge to ground water. Surface runoff can travel downslope to areas containing permeable soils or debris and infiltrate there or it can flow into topographic depressions and gulleys. During small storm events, little water may accumulate in gulleys, and surface runoff may be negligible. However, during larger storm events, significant flow can occur and water in the gulleys can travel several miles down the mountain slopes. As surface runoff flows across the piedmont alluvium and channel deposits of the arroyos, water is lost to the alluvium, locally recharging the alluvium. Pediment

On the western side of the Chocolate Mountains, ground water recharges primarily at the higher elevations and flows to the west and southwest beneath the piedmont surface. Recharge

is believed to be the source of most of the ground water encountered at the mine site, occurring predominantly in the gneissic bedrock and less frequently in the conglomerate. Ground water then flows beneath the mine site moving towards the center of the Imperial Valley to replenish the thick alluvial and valley-fill deposits found there.

Near the mine, the alluvium is typically unsaturated. There may be some areas where the alluvium holds water locally in perched zones, particularly along arroyos after storm events. In these areas, the alluvium may be an important source of water for local vegetation and may occasionally feed seeps after storm events. The alluvium does not provide a major permanent source of water.

2.2.2 Mine Site Scale

The same hydrologic processes and general conceptual model that hold at the subregional scale also apply on the mine site, with one exception: on the mine site, little or no recharge to ground water is expected to occur due to the combined effects of reduced precipitation at the lower elevations and the presence of less-permeable ground surfaces disturbed by mining. However, limited infiltration can occur and eventually become recharge, particularly on the rough, untrafficked portions of the waste rock facilities. Recharge that may occur in these areas is not expected to reach the water table for many years due to the considerable depth to ground water beneath the ground surface and other factors such as compaction and grading of the facilities. Therefore, replenishment of ground water reserves due to recharge is generally a relatively unimportant process across most of the mine site. Where it does occur, recharge has been estimated to be as low as 0.20 inches per year (in/yr) (SMI, 1997).

The conceptual model of hydrologic processes that occur in and around the mine pits is summarized in Figure 2-4. In this view, incident precipitation that strikes the existing pit lakes (as direct precipitation) simply adds to the volume of the lakes. Precipitation incident on the pit walls either contributes to surface runoff, or it evaporates or infiltrates. The amount that runs off either reaches the lakes adding to their volume or it travels only a short distance

from the pit walls, although some evidence of runoff can be observed on the highly compacted haul roads. It is possible that infiltration and recharge to ground water may occur locally, but this has not been quantified. Salt cedar and other vegetation observed on pit high walls are currently thriving on infiltration and local discharge at seeps.

Evaporation from lake surfaces and pumping of water for haul road dust control are the principal processes acting to limit the size of the existing pit lakes. In the desert climate present at the mine, evaporation is significant, amounting to approximately 80 in/yr (Hely and Peck, 1964; National Weather Service (NWS), 1982).

The primary source of influx to the pit lakes is ground water inflow. Current inflows are caused by the local lowering of ground water levels around the mine pits (from their initial, pre-mining levels) due to pit dewatering and evaporative loss from the lake surfaces. When mining operations have ceased and dewatering of the pits is no longer practiced, ground water inflow will continue, allowing water levels to rise and permanent lakes to develop in the pits. The water levels in each lake will rise until, at a certain elevation (called the near steady-state equilibrium elevation), evaporative losses from the lake surface will exactly equal ground water inflow. Although lake elevations and volumes will not change significantly after near steady-state equilibrium is attained, the concentration of chemical constituents dissolved in the lake waters will increase over time due to the process of evapoconcentration.

2.3 HYDROLOGIC CONDITIONS

2.3.1 Climate Data

Meteorological data from four National Climatic Data Center recording stations in Yuma, Arizona were complied and reviewed in order to establish a long term record that could be used to represent weather conditions in the vicinity of the mine pits. Temperature and precipitation data recorded at the Yuma airport were assumed to be representative of conditions at the Mesquite Mine.

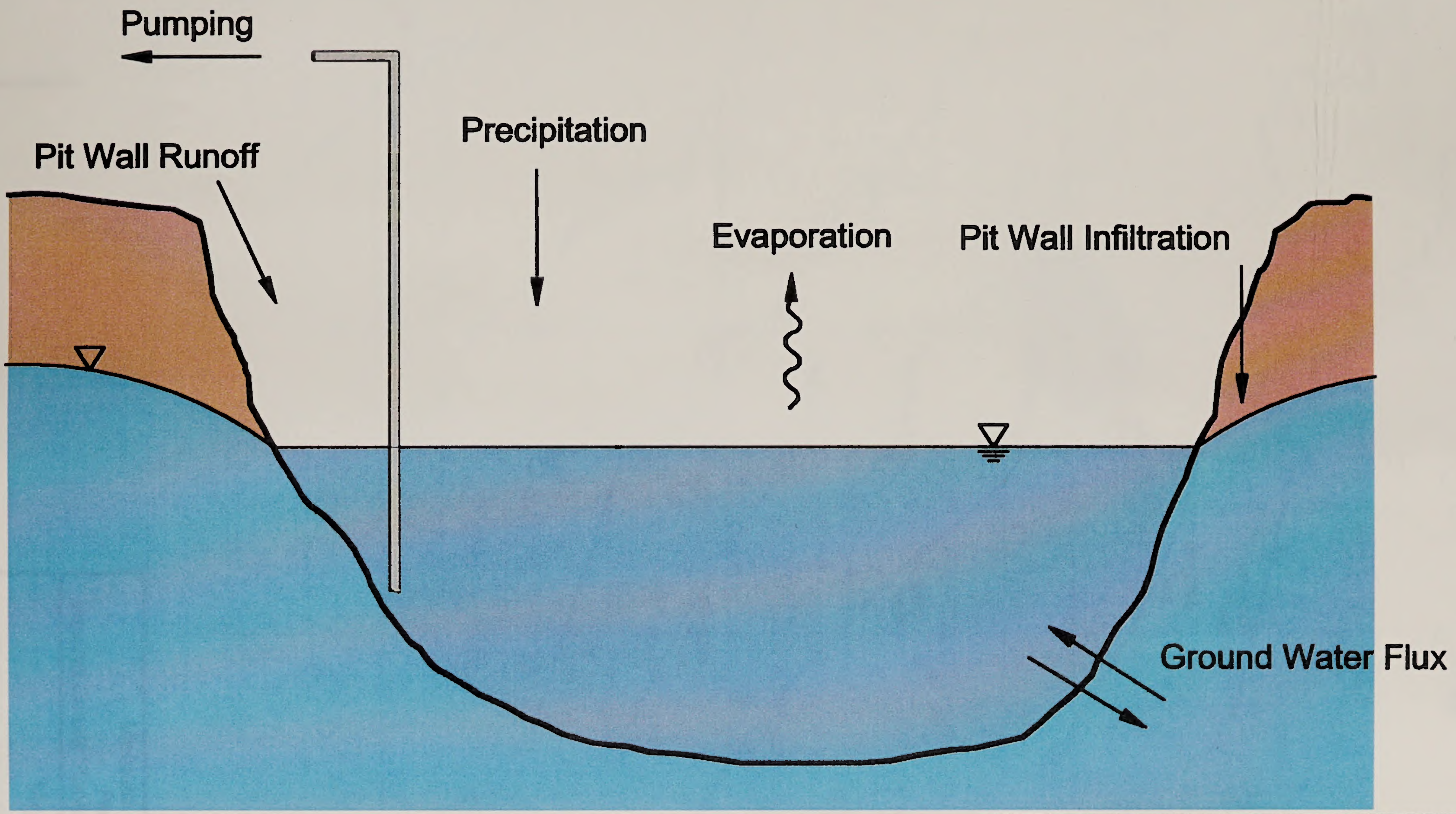
The mean annual temperature at the Yuma airport NWS Station is 74.3 °F, based on the period 1948 to 1995. The hottest month is July (93.7 °F) and the coldest month is December (56.5 °F). Pan evaporation data are not recorded at the Yuma airport, therefore an average annual evaporation rate of 80 in/yr for shallow ponds and lakes derived from NWS integrated mapping was used to represent conditions at the mine site (NWS, 1982). This value is consistent with the mean annual lake evaporation rate estimated by Hely and Peck (1964) for the Lower Colorado River-Salton Sea area.

The mean annual precipitation at the Yuma airport is 2.96 in/yr based on 47 years of record from 1948 to 1995. Precipitation can occur in trace amounts throughout the year but the highest precipitation months are August, December and January, on average. Typically, May and June are the driest months with less than 0.05 in of rainfall.

2.3.2 Ground Water Elevations, Gradients and Flow Direction

Pre-mining Ground Water Elevations

In order to evaluate the potential affects of mining on ground water resources, it was necessary to estimate ground water elevations that existed before mining began. Because no record of ground water elevations exists for wells prior to mining or during the first 10 years of mining, depth to water information observed in exploration boreholes was utilized to infer the surface of the pre-mining water table. A pre-mining ground water elevation map (Figure 2-5) was constructed based on the first water encountered during exploration drilling (Table A.1, Appendix A). Only information from exploration boreholes drilled from 1983 through 1984 was used for map construction. Exploration holes drilled after this period were assumed to be impacted by the effects of mining, and were therefore excluded. In general, the direction of ground water flow observed before mining (and shown in Figure 2-5) was to the southwest with an average gradient of 0.030.



Mesquite Mine Expansion
Prepared for
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Figure 2-4

Hydrologic Conceptual Model
for Pit Lakes

Prepared by
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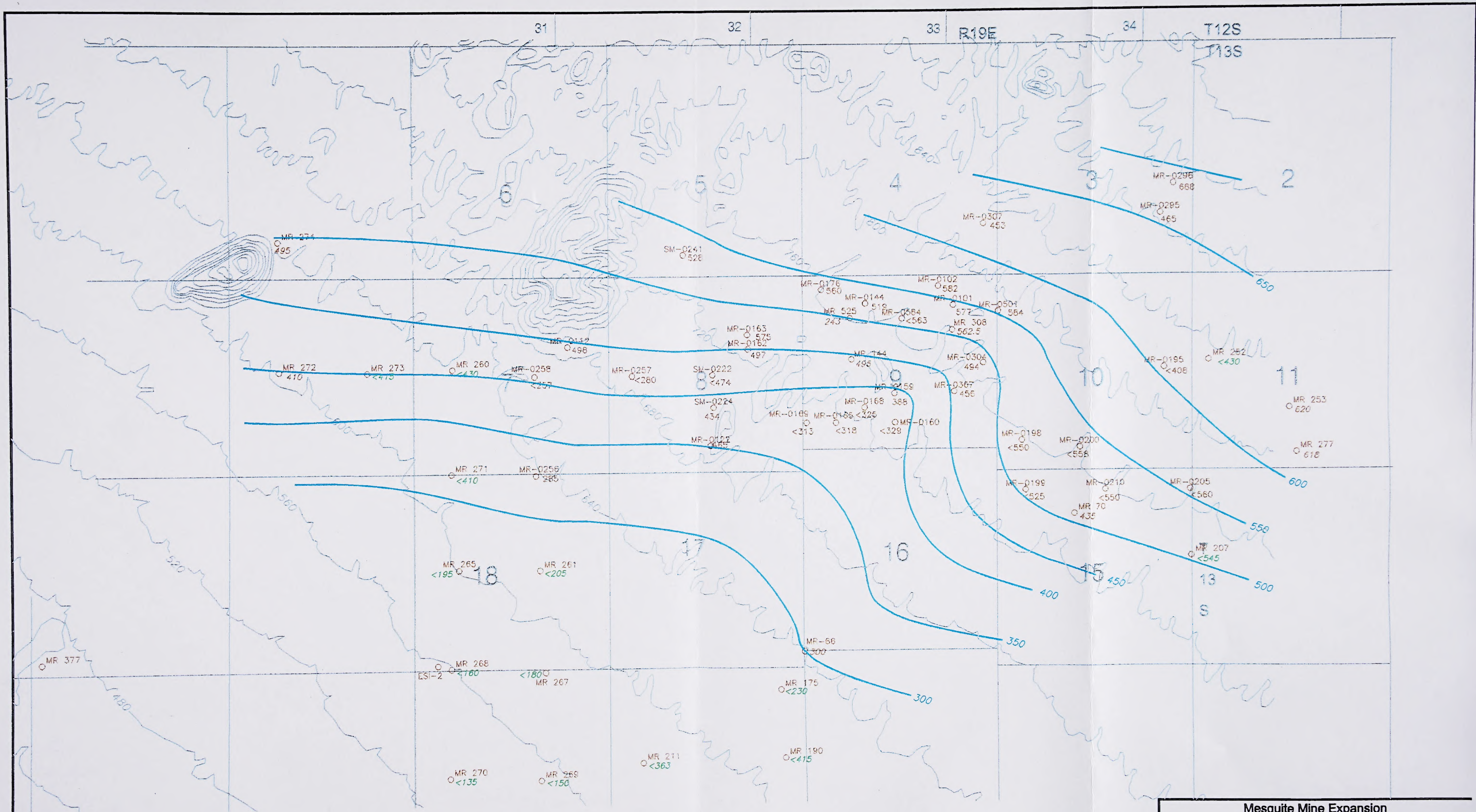

Explanation

MR-0176 ○ Borehole
560 Elevation of First Encountered Water (feet msl)
<135 Ground Water Not Encountered Above Total Depth of Borehole
300 Estimated Water Table Contour
Topographic Contour (feet msl)

N

0 2500
Scale in Feet

Note: Topographic Base from Butler Roach Group, Inc. (1995)

Mesquite Mine Expansion
Prepared for
Imperial County Planning and Building Department

Figure 2-5

Estimated Pre-Mining Ground Water Elevation Map

Prepared by
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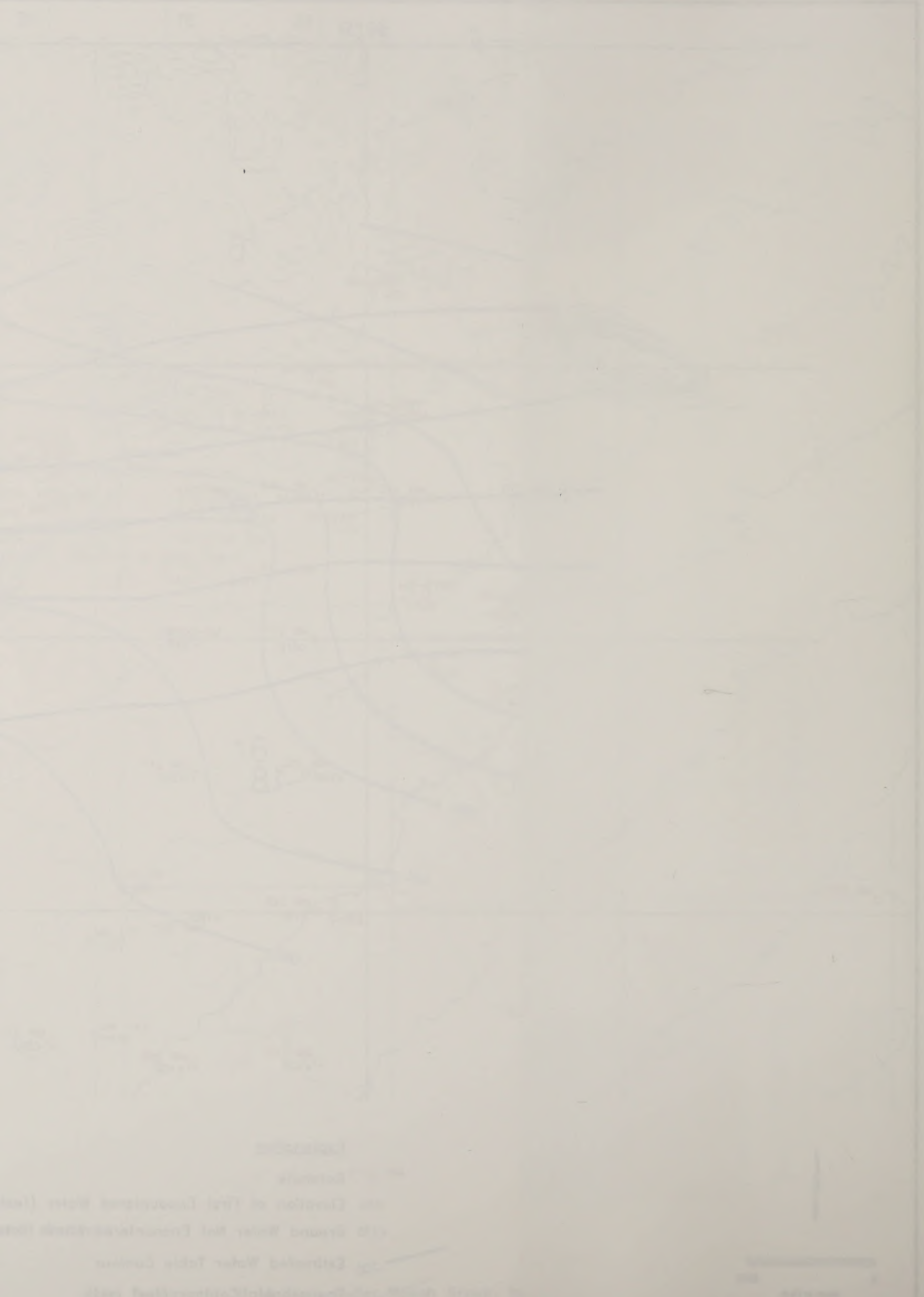
BCI-fig2-5.dwg


Explanation
Borehole
Elevation of First Encountered Water (feet
Ground Water Not Encountered Within
Estimated Water Table Contour

Current Conditions

Seven ground water monitoring wells (GW-1 through GW-7) have been used for water level monitoring at the mine site since April 1994, the first available measurement date (Figure 1-2). Hydrographs for these wells are presented in Figure 2-6 and supporting data used for construction of the hydrographs are provided in Table A.2 of Appendix A. Inspection of the water levels measured in the wells (Figure 2-6) shows that they are very stable, varying within only a five-foot range for the period of record with the exception of a few measurements at GW-4, GW-5 and several measurements at GW-7 (Figure 1-2). GW-4 and GW-7 are located in the area between the Big Chief and Vista Pits, and therefore may be affected by mining activities. GW-5 is located downgradient from the heap leach pads. The hydrographs indicate that the monitoring wells have not been affected by pit dewatering operations, with the possible exception of GW-7.

The depth to water in the wells varies from 285 feet below ground surface (bgs) at GW-9 (northeast), to 218 feet bgs at GW-7 (north-central), and 312 feet bgs at GW-1 (south). The locations of these wells, in addition to other less frequently monitored wells are illustrated in Figure 1-2. A summary of well completion information including hydrostratigraphic units that the wells are completed in is presented in Table A.4 of Appendix A.

Additional water level measurements have been collected less frequently at GW-8A, GW-9, MCR-80, LGW-1, LGW-2 and the pit lakes. The most current water level measurements (obtained in May through July 1999) were used to construct the ground water elevation map presented in Figure 2-7. The ground water elevation measured at MCR-80 (536 feet) was not used in the creation of the water level map because this well is completed between 401 and 1,002 feet bgs, in a much deeper screened interval than the other wells that were measured. MCR-80 is believed to exhibit a composite ground water level representing multiple water-bearing units.

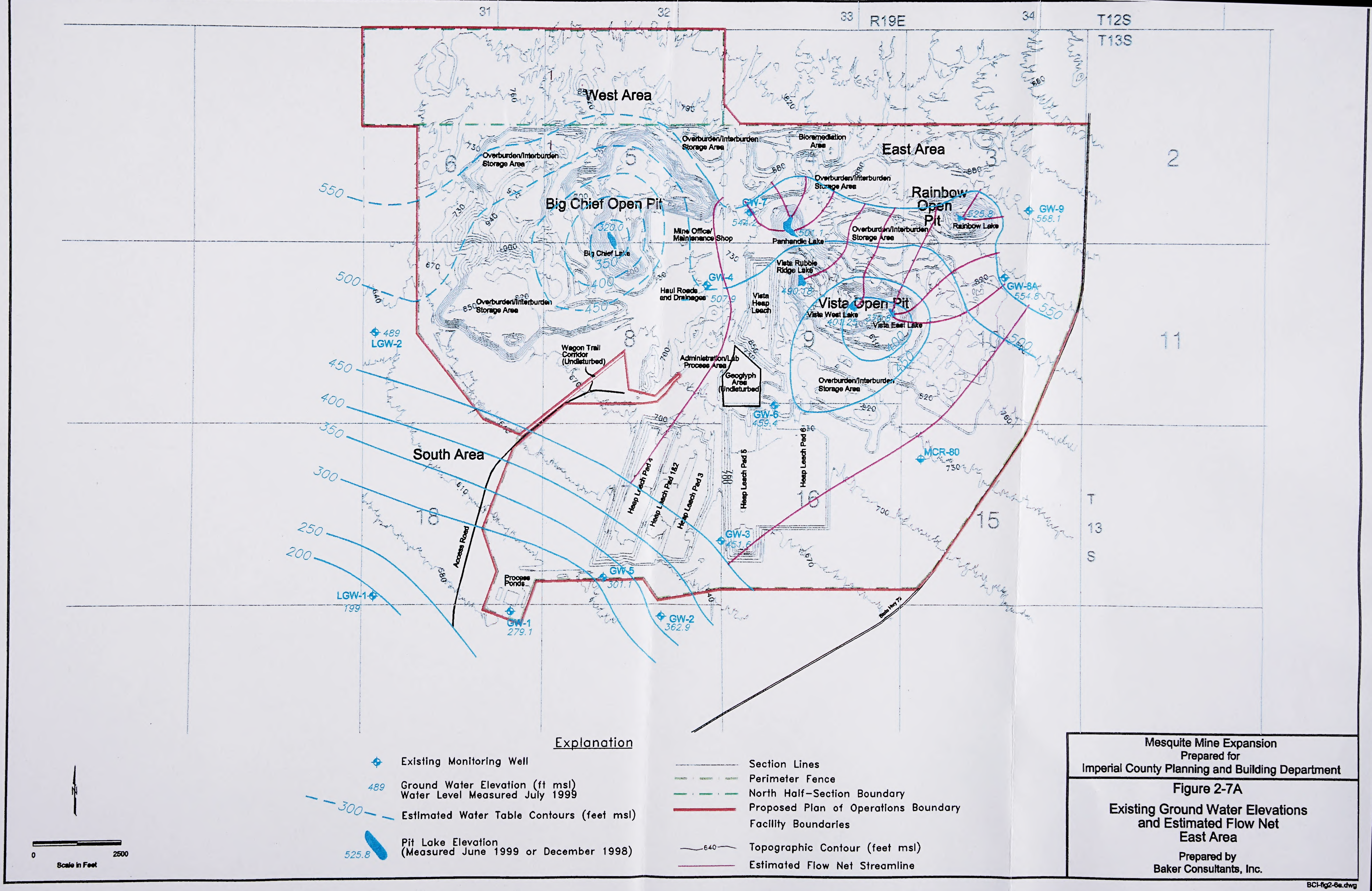
Although the wells shown in Figure 2-7 are not all completed in the same hydrostratigraphic unit and detailed well completion information is often lacking, the water levels at each well are expected to approximate ground water elevations in the uppermost water-bearing unit, and, therefore, to be representative of the water table surface. The existing hydraulic gradient is generally to the southwest ranging from 0.045 in the area of the mine pits to 0.01 south of the mine pits and steepening again to 0.037 in the vicinity of the leach pads. The apparent steepening of the hydraulic gradient in the southern portion of the mine site is thought to be caused by a reduction in the permeability of the aquifer in this area. This is supported by lower reported hydraulic conductivity estimates obtained from packer tests and slug tests performed in the south by ESI (1993) compared to pumping test results reported for MW-8A and MW-9 by SMI (1998a).

Adjacent to the mine pits, dewatering of the pit lakes and evaporation from the lake surfaces create hydraulic stress on the local ground water flow system, causing the lakes to act as individual hydraulic sinks. The hydraulic stress alters the hydraulic gradient, causing much of the ground water flowing from the northeastern portion of the site to be captured by the pit lakes and sumps. Ground water not captured in the pit lakes continues to flow toward the southwest in response to the hydraulic gradient.

2.3.3 Pit Lake Water Balance

Water balance calculations were performed for each of the six existing pit lakes: Big Chief, Rainbow, Vista East, Vista West, Vista Panhandle and Vista Rubble Ridge (Figure 2-7). Each of the water balance components discussed in the pit lake conceptual model were considered (Section 2.2). The components of the water balance are related as follows:

$$Q_T = Q_{GW} + Q_{DP} + Q_{RO} - Q_E - Q_{pump}$$



Mesquite Mine Expansion
Prepared for
Imperial County Planning and Building Department

Figure 2-7A
Existing Ground Water Elevations and Estimated Flow Net
East Area

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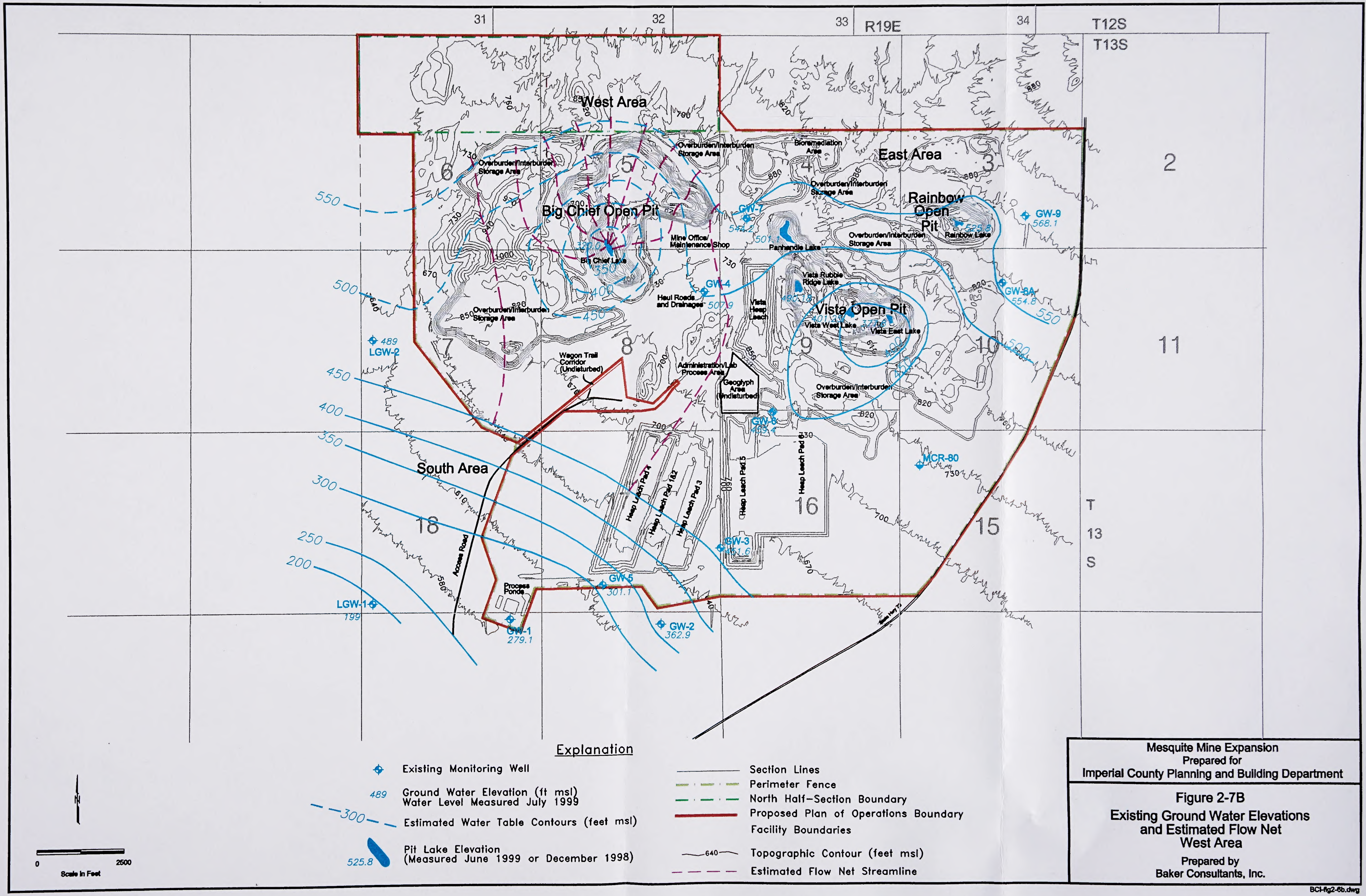
BCI-fig2-6a.dwg



Explanation

⌖	Existing Monitoring Well
489	Ground Water Elevation (ft msl) Water Level Measured July 1999
—300—	Estimated Water Table Contours (feet msl)
525.8	Pit Lake Elevation (Measured June 1999 or December 1998)
———	Section Lines
— · —	Perimeter Fence
— · —	North Half–Section Boundary
———	Proposed Plan of Operations Boundary
	Facility Boundaries
—640—	Topographic Contour (feet msl)
— — —	Estimated Flow Net Streamline

Mesquite Mine Expansion
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Figure 2-7B
Existing Ground Water Elevations and Estimated Flow Net
West Area

Prepared by
Baker Consultants, Inc.

BCI-fig2-6b.dwg

where

Q_T = total influx to lake in cubic feet per day (cfd),
Q_{GW} = ground water influx to lake (cfd),
Q_{DP} = direct precipitation to lake surface (cfd),
Q_{RO} = runoff flux to the lake from pit walls (cfd),
Q_E = lake surface evaporation loss (cfd), and
Q_{pump} = water pumped from lake (dewatering) (cfd).

As discussed in Section 2.2, runoff from the pit walls to the pit lake is expected to be minimal in this setting and has been assumed to equal zero for these calculations. Any error introduced by this assumption is expected to be minimal compared to the uncertainties reflected in other components of the mass balance.

An average annual lake evaporation rate of 80 in/yr and precipitation rate of 2.96 in/yr were applied to all water balance calculations. The elevations of the pit lakes were either surveyed directly in June 1999 or determined from the December 1998 aerial survey. Lake surface areas were determined from detailed topographic maps supplied by the mine. The areas and unit rates were then utilized to calculate the Q_E and Q_{DP} fluxes.

The dewatering rate for each pit was estimated from logs of dewatering and road watering operations maintained by the mine. Three years of record were available for calculation of the average monthly pumping rate from each mine pit. The most recent rates available were utilized to estimate a representative Q_{pump}.

The values of Q_{pump}, Q_{DP},, and Q_E and the results from the water balance determined for all the lakes are summarized in Table 2.2. In general, evaporative losses dominate the water balance of the larger lakes, particularly the Vista Rubble Ridge and Panhandle lakes which are not currently being pumped for dewatering purposes. The lake with the highest ground water inflow rate is the Big Chief lake, where Q_{GW} is estimated to be approximately 49 gpm. This

ground water influx is relatively large compared with 4.4 gpm at the Rainbow Pit and a total of 28 gpm for all four lakes within the Vista Pit. The higher rate of inflow into the Big Chief Pit indicates that the fractured gneiss that forms the bottom and walls of the pit is more permeable than that exposed in the Rainbow Pit, assuming that all other factors affecting the water balance are the same.

2.3.4 Site-Wide Water Balance

A preliminary water balance was calculated for the uppermost water-bearing zone present in the eastern and western areas of the mine site. The water balance was derived from two flow nets (Figures 2-7A and B) constructed separately for the eastern and western subareas due to the apparent differences in aquifer hydraulic properties near the Big Chief Pit, compared to the eastern portion of the mine site. Information used to construct the flow nets included pit lake and ground water influx rates discussed in the previous section. In the eastern area, reliable ground water elevation data were available from wells (Figure 2-7A). However, water level measurements from wells were not available for the northwestern portion of the site. The flow net constructed for the Big Chief Pit (west area shown on Figure 2-7B) was, therefore, based on estimated water levels encountered during exploration drilling. This introduces a measure of additional uncertainty into calculations of the water balance in this area.

Based on the approximate ground water elevations and hydraulic gradients illustrated in Figure 2-7A, two flow nets were constructed to estimate the site-wide water balance. Assuming isotropic conditions and continuity of flow within each flow net, the graphical solution includes 12 streamtubes in the eastern flow net (Figure 2-7A) and eight streamtubes in the western flow net (Figure 2-7B), with each streamline oriented orthogonal to equipotential lines. The streamlines are separated along the 550-foot above mean sea level (msl) equipotential contour by 1,000 feet, to form streamtubes between the streamlines. The mesh created by the equipotential lines and streamlines provides a spatial discretization of ground water flow through the two subareas of the mine. Each flow net illustrates the contribution of ground

water influx to the pit lakes, as compared to flow that bypasses the pits and flows south. The flow net solution assumes near-horizontal flow and vertical gradients equal to zero.

The eastern flow net (Figure 2-7A) utilizes the water balance results for the current Rainbow and Vista pit lakes, current ground water and pit lake elevation data, an average hydraulic conductivity of 0.045 ft/d for gneissic bedrock and a hydraulic gradient of 0.045 south of the 550-foot ground water elevation contour. Using the flow net, flux through the vertical cross-sectional area of each flow cell can be calculated for a given hydraulic gradient and hydraulic conductivity, while maintaining continuity of flow between adjacent upgradient and downgradient cells. Trial-and-error solution of the flow net matches inflow to the flow net at the 550-foot ground water contour, the fluxes lost from the lakes and the estimated outflux at the 450-foot contour. In this solution, a saturated effective thickness for the aquifer of 300 feet yields a ground water flux of 3.2 gpm per streamtube, or 38.4 gpm for the 12 streamtubes in aggregate. The distribution of streamlines defines the direction and magnitude of flow to the pit lakes and to the 450-foot boundary of the flow net.

A summary of streamtube accounting for the eastern subarea of the mine site is presented in Table 2.3. The water balance achieved accounts for 92 percent of the calculated inflows, which represents an eight percent water balance error. This is a reasonable discrepancy given the uncertainty in input variables.

The flow net for the western subarea of the mine site was constructed in a similar manner (Figure 2-7B). In the western subarea, ground water elevations were estimated from depth to first-encountered water in exploration boreholes because little is known about current ground water levels. Water levels at the pit lake and at well GW-4 are the only measured data. The Q_{GW} from the lake water balance (Section 2.3.3) was also used for the calculations. The aquifer thickness derived from the eastern flow net was assumed to apply in the western area. The average hydraulic gradient along the 550-foot ground water contour (northern boundary of the flow net) was estimated to be 0.06 from Figure 2-7.

Trial-and-error solution of the flow net indicated that hydraulic conductivity in the western subarea was higher than in the eastern flow net. In order to achieve a balance, the hydraulic conductivity had to be increased to 0.08 ft/d, yielding a ground water flux of 7.5 gpm per streamtube, or 60 gpm overall.

A summary of streamtube accounting for the western subarea of the mine site is provided in Table 2.3. The results from the water balance account for 94 percent of the calculated inflow to pit lakes in the area. This represents a six percent error when compared to inflow. This is an acceptable result given the uncertainty in many of the input variables. Although the water balance for the western area appears reasonable, these results should only be viewed as a preliminary approximation of flux in the ground water flow system. The flow net analysis can be improved as more site specific information becomes available.

2.4 EXISTING WATER QUALITY

2.4.1 Lake Water Quality

The chemical composition of waters in four of the existing lakes has been monitored during five sampling events conducted between December 1997 and July 1999. During this period, lake depths have varied from approximately three to four feet (the present depth of Rainbow lake) to approximately seven to 10 feet as a result of ground water inflows, mine pit dewatering activities and lake surface evaporation. A complete tabulation of water quality data available for the lakes along with supporting documentation is presented in Appendix B.

The mean water quality observed in the Big Chief lake, Vista West lake, Vista East lake and Rainbow lake is summarized in Table 2.4. The concentrations of chemical constituents reported in the table represent the geometric means of the eight water samples analyzed to date. Geometric means were used because the distributions of chemical concentrations are typically log-normal. As shown in the table, lake waters in the existing mine pits are typically

alkaline, slightly to moderately saline, and low in dissolved trace metals with the few exceptions noted below.

Lake pH values range between 8.3 and 8.9 with the highest pH values occurring in Rainbow lake. The buffering capacity of the lake waters is relatively high as indicated by total alkalinity concentrations ranging from 258 to 334 mg/L of $CaCO_3$. Total alkalinity can be largely attributed to dissolved bicarbonate. The concentration of total dissolved solids (TDS) in the four lakes ranges from 1,400 to 3,600 mg/L and Vista West is the most saline.

The lake waters are predominantly sodium-chloride/sulfate waters containing lesser amounts of calcium, magnesium, bicarbonate and silica. The relative concentrations of the major ions dissolved in each lake are depicted in the Stiff diagrams (Stiff, 1951) shown in Figure 2-8. This figure illustrates that all the lakes show basically the same chemical signature characterized by relatively high sodium, sulfate and chloride concentrations, as might be expected of young brackish lakes developing in an arid inland hydrologic basin. The relatively exaggerated Stiff diagram developed for the Vista West lake is based on a single water sample collected on 4/26/99 when the lake was very shallow and highly concentrated, suggesting that this might reflect a suitable end-member chemistry for the whole series of lakes. When this water sample is included in the average concentration of all samples collected from the Vista East and West lakes, the chemical signature of the combined Vista lakes (identified as VA in Figure 2-8) is virtually indistinguishable from the signature of the Rainbow lake.

Selected water quality goals for the protection of California ground water and surface water resources are provided in Table 2.5 (Marshack, 1998). Primary and secondary maximum contaminant levels (MCLs) are drinking water standards applied to public water supply systems; agricultural water quality goals are criteria established to be protective of agricultural uses of water; and the ambient aquatic criteria (US Environmental Protection Agency (USEPA) National Ambient Water Quality Criteria) are established for the protection of freshwater aquatic life in surface waters. Although current or future anticipated water uses at the Mesquite

Mine do not include human consumption, agricultural or recreational uses, the water quality goals presented in the table and intended for comparison purposes, to provide benchmark comparisons of historical, current and potential future water quality, as was done in previous studies (SMI, 1998a; BRG, 1995; ESI, 1987).

Comparison of the chemical composition of the lakes with the water quality goals summarized in Table 2.5 indicates that waters in one or more of the lakes exceed threshold values established for antimony, boron, chloride, fluoride, nitrate/nitrite, selenium, sulfate and TDS. The concentration of selenium detected in Big Chief lake is currently at the primary MCL and concentrations of selenium present in Vista West lake and Rainbow lake exceed this value. Water in Rainbow lake also exceeds the primary MCL set for antimony. Fluoride levels in Vista East, Vista West as well as Rainbow lake exceed the primary MCL for fluoride. The primary MCL for nitrate/nitrite is currently exceeded in Vista West lake (as was the case in December 1997 in Vista East lake). All lake waters sampled within the last year and one-half exceed secondary MCLs for chloride, sulfate and TDS. Boron and chloride concentrations exceed agricultural water quality goals established for these constituents. Finally, the mean concentration of cadmium detected in Vista East lake has reached the threshold value set for the protection of aquatic life (national ambient aquatic four-day average of 0.0019 mg/L based on a hardness of 230 mg/L $CaCO_3$ measured in Big Chief lake.

2.4.2 Ground Water Quality

Previous Investigations

The quality of ground water in the vicinity of the Mesquite Mine has been described in several investigations conducted to support the EIS/EIR and Plan of Operation documents prepared for the VCR Mining Project, Mesquite Project, Mesquite Regional Landfill and Rainbow Pit Expansion (St. Clair Research Systems, Inc., 1984; ESI, 1987; ESI, 1993; BRG, 1995; SMI, 1997 and SMI, 1998b). The typical ground water chemistry reported for the hydrologic subbasin in which the mine is located is shown in Table 2.6 (excerpted from ESI, 1987). The

data in the table represent ground water quality conditions observed in various colluvial and bedrock hydrostratigraphic units during the period 11/82-4/92 at monitoring wells located close to the Mesquite Mine. The locations of monitoring wells that were sampled are shown in Figure 1-2, although WT-2, SM-63 and the Singer Well no longer exist.

The baseline ground water quality at the mine site reported by ESI (1987) was found to be generally poor and unsuitable for drinking and irrigation purposes without treatment (Table 2.6). Values of specific conductance and TDS were high, ranging from 960 to 3,100 mg/L and averaging about 1,000 mg/L. Ground water pH varied from neutral to moderately alkaline (pH 7.2-9.2). In general, the water quality was characterized as saline and high in chloride, fluoride, sulfate, arsenic, chromium, iron and manganese (the latter five constituents being reported as total rather than dissolved concentrations). In addition, St. Clair Research Systems, Inc. (1984) reported that ground water in the vicinity of the mine exceeded California drinking water standards for turbidity and mercury, as well as irrigation standards established for boron, chromium, iron, manganese, sodium and zinc.

Existing Ground Water Quality

Under mine operation permit requirements, ground water quality is monitored on a quarterly basis in monitoring wells GW-1 through GW-7 for the following chemical constituents: pH, specific conductance, temperature, arsenic, copper, cyanide (total), cyanide (free), iron, nitrate/nitrite, silver, sulfate, and TDS. Monthly analyses are also available for the above constituents for the period 1995-1998. Ground water samples are analyzed by standard methods of chemical analysis by SVL Analytical Laboratories in Kellogg, Idaho (see methods of chemical analysis listed in SMI, 1997). Because the constituents of interest for permitting do not provide a chemical charge balance for water samples, a supplemental ground water sampling round was conducted on 7/19/99-7/20/99 to establish current baseline conditions based on a complete analysis of major ions and trace metals. Monitoring wells GW-8A and GW-9 were not sampled in the July 1999 sampling event. The most recent chemical analyses

available for these wells are from water samples collected on 8/26/97 and 7/19/97, respectively (SMI, 1997).

Baseline ground water quality conditions observed in monitoring wells located adjacent to the existing mine pits are summarized in Table 2.7. Well completion information reported by ESI (1993) and SMI (1997) indicates that GW-1, GW-2, GW-3, GW-5 and GW-6 are screened in Tertiary conglomerate, GW-4 is screened in biotite or hornblende gneiss, and GW-8A and GW-9 are screened in mafic gneiss (Table A.4, Appendix A). Inspection of the lithologic log for exploration borehole MR-267 located close to GW-1 indicates that the screened interval of this well is actually located in an andesitic basalt unit that locally intrudes the Tertiary conglomerate materials deposited in the area south of the mine process ponds (Figure 1-2). Ground water quality data are not presented for GW-7 because no well construction information is available for this monitoring well, and therefore, the hydrostratigraphic unit being sampled is unknown.

The major ion chemistry of ground water in the mine pit area is depicted in Figure 2-9. The Stiff diagrams shown in the figure indicate that the ground water sampled from existing monitoring wells has a sodium-chloride/sulfate chemical signature similar to that observed in the pit lakes (Figure 2-8). This is to be expected since the lakes are being sustained primarily by ground water inflows. Three observations are apparent from the figure: (1) the chemical signature for GW-8A looks remarkably similar to that of the East Vista lake; (2) the hydrostratigraphic units that the wells are screened in are interconnected and cannot be distinguished from each other on the basis of major ion chemistry; and (3) ground water monitored at GW-1 and GW-2 is more saline than that observed at the other wells.

Inspection of Table 2.7 indicates that ground water at the mine site is currently brackish and slightly to moderately alkaline, with pH values ranging from 7.7 to 9.4, and TDS concentrations ranging from 801 to 1,700 mg/L. Major dissolved chemical species include sodium, calcium, magnesium, chloride, sulfate, bicarbonate and silica. Minor species include potassium, boron and fluoride. The elevated levels of arsenic, chromium, iron and zinc

reported by ESI (1987) are not currently present. However, as reported previously, fluoride, sulfate and TDS concentrations detected in most wells still exceed their respective primary MCLs (Table 2.5), and the present concentrations of these chemical constituents are quite similar to the historic concentrations reported by ESI (1987) (Table 2.6). Concentrations of manganese in GW-1 and GW-8A exceed the secondary MCL for manganese but are generally lower than those reported historically. Ground water quality in all wells at the mine site exceeds secondary MCLs established for chloride, sulfate and TDS. In addition, all wells exceed the agricultural water quality goals established for boron and chloride.

Changes in the concentrations of selected chemical constituents monitored over the last five years (April 1994-July 1999) are illustrated in the concentration versus time plots (chemical hydrographs) shown in Figures C-1 to C-9 of Appendix C. Plots are presented for pH, electrical conductivity (EC), temperature, TDS, arsenic, copper, iron, sulfate and nitrate/nitrite. A complete listing of ground water quality data used to construct the hydrographs is provided in Table C.1 of Appendix C. The chemical hydrographs indicate the following ground water quality conditions:

- pH values measured in GW-6 tend to be higher than in the other wells.

- EC levels and TDS concentrations observed in GW-1 and GW-2 are consistently the highest and those measured in GW-3 are the lowest.

- No distinct trends in arsenic concentrations are apparent. When detected, arsenic is present at generally low levels, except in April 1996 when concentrations greater than 0.05 mg/L were detected in GW-1 and GW-3.

- Concentrations of copper and nitrate/nitrite are generally low or below their respective analytical detection limits.

- Concentrations of iron are highly variable and appear to be highest in GW-2 and GW-6 during the period of record.

- Concentrations of sulfate detected in GW-1 through GW-4 are relatively consistent over time whereas those detected in GW-5 and GW-6 are highly variable. Sulfate concentrations are highest in GW-1 and lowest in GW-3.

2.5 ROCK-WATER INTERACTIONS

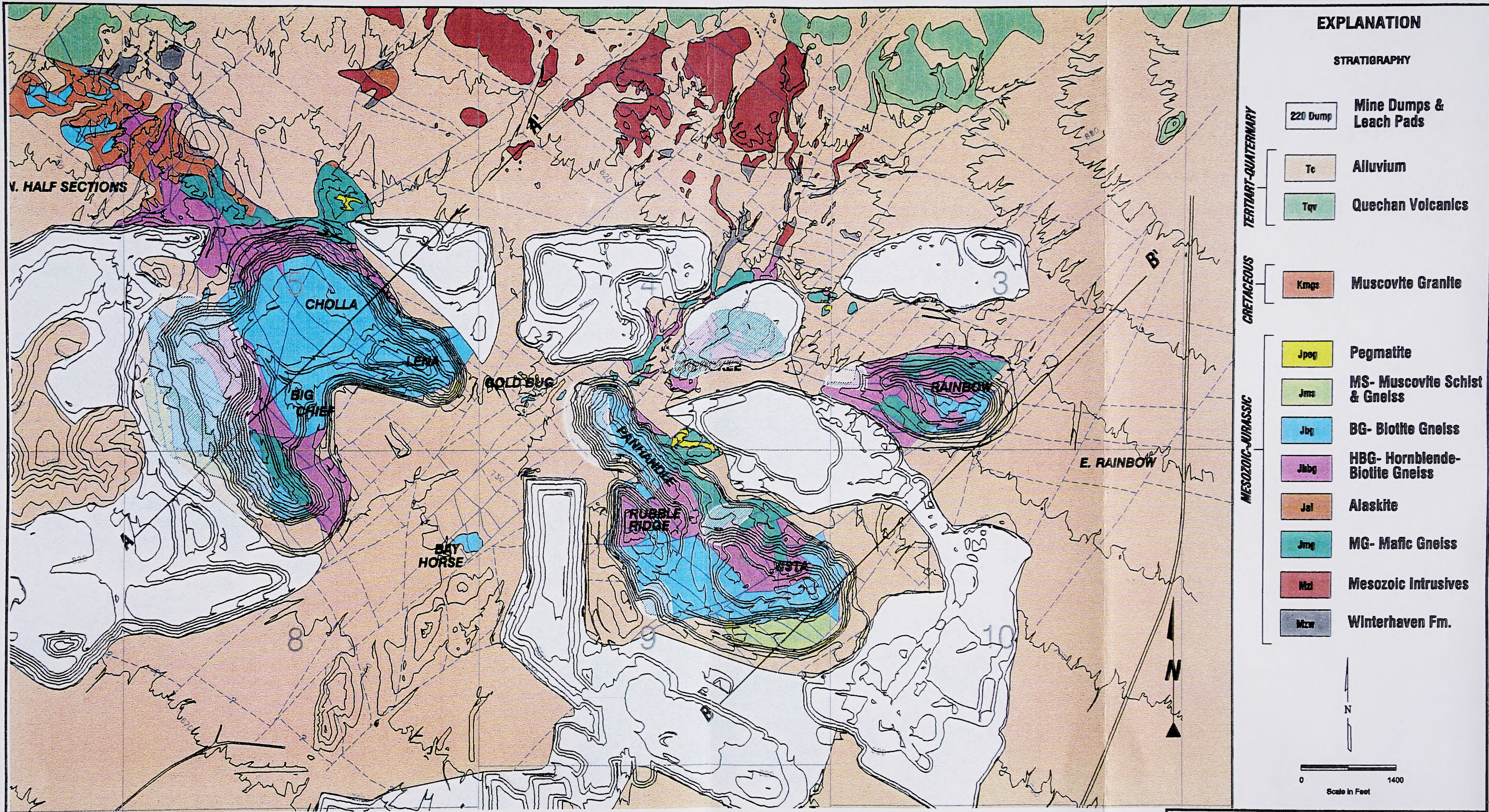
2.5.1 Geochemical Rock Types

The age, mineralization and alteration characteristics of geologic units encountered at the Mesquite Mine are summarized in the tectono-stratigraphic column presented in Figure 2-2 (Ferrell et al., 1999). The stratigraphic column represents the most recent geologic interpretation of the major rock units that are exposed in the walls of the Big Chief, Vista and Rainbow Pits (shown in Figure 2-1). The geologic interpretation expressed in the figure differs somewhat from those based on previous mine exploration activities conducted by Gold Fields Operating Company, SFPG, and earlier EIS/EIR investigations which are provided for comparison in Table 2.1.

The principal wall rock materials exposed in the mine pits are as follows:

Quaternary Alluvium (Qal) –A thin veneer of unconsolidated alluvial sediments present primarily north and west of the mine site.

Tertiary Conglomerate (Tc) –Variably consolidated, multi-lithic conglomerate interbedded with silt, clay and basalt which comprises the majority of mine overburden materials. In the vicinity of the mine pits, the conglomerate is matrix supported, commonly intruded by pegmatite sills and rests unconformably on bedrock. In the Rainbow Pit area, this unit has been previously subdivided into three subunits: (1) Conglomerate (Tcg/Tcg1), (2)



Mesquite Mine Expansion
Prepared for
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Figure 2-1

Existing Geology

Prepared by
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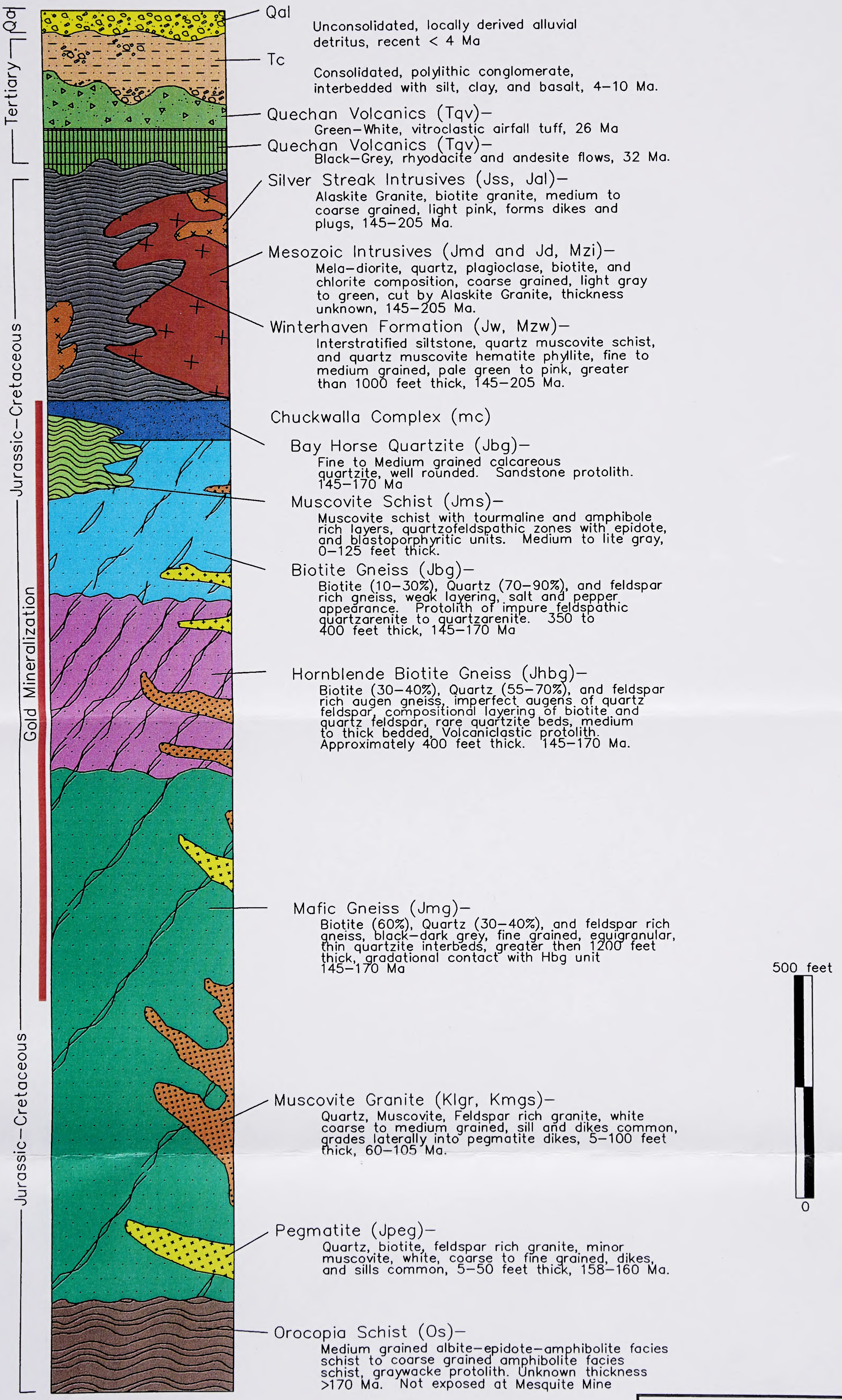
Source: Newmont Mining Corporation

BCI-fig2-1.dwg



Qal
Unconsolidated, locally derived alluvial detritus, recent < 4 Ma

Tc
Consolidated, polylithic conglomerate, interbedded with silt, clay, and basalt, 4–10 Ma.

Quechan Volcanics (Tqv)–
Green–White, vitroclastic airfall tuff, 26 Ma

Quechan Volcanics (Tqv)–
Black–Grey, rhyodacite and andesite flows, 32 Ma.

Silver Streak Intrusives (Jss, Jal)–
Alaskite Granite, biotite granite, medium to coarse grained, light pink, forms dikes and plugs, 145–205 Ma.

Mesozoic Intrusives (Jmd and Jd, Mzi)–
Mela–diorite, quartz, plagioclase, biotite, and chlorite composition, coarse grained, light gray to green, cut by Alaskite Granite, thickness unknown, 145–205 Ma.

Winterhaven Formation (Jw, Mzw)–
Interstratified siltstone, quartz muscovite schist, and quartz muscovite hematite phyllite, fine to medium grained, pale green to pink, greater than 1000 feet thick, 145–205 Ma.

Chuckwalla Complex (mc)

Bay Horse Quartzite (Jbg)–
Fine to Medium grained calcareous quartzite, well rounded. Sandstone protolith. 145–170 Ma

Muscovite Schist (Jms)–
Muscovite schist with tourmaline and amphibole rich layers, quartzofeldspathic zones with epidote, and blastoporphyritic units. Medium to lite gray, 0–125 feet thick.

Biotite Gneiss (Jbg)–
Biotite (10–30%), Quartz (70–90%), and feldspar rich gneiss, weak layering, salt and pepper appearance. Protolith of impure feldspathic quartzarenite to quartzarenite. 350 to 400 feet thick, 145–170 Ma

Hornblende Biotite Gneiss (Jhbg)–
Biotite (30–40%), Quartz (55–70%), and feldspar rich augen gneiss, imperfect augens of quartz feldspar, compositional layering of biotite and quartz feldspar, rare quartzite beds, medium to thick bedded, Volcaniclastic protolith. Approximately 400 feet thick. 145–170 Ma.

Mafic Gneiss (Jmg)–
Biotite (60%), Quartz (30–40%), and feldspar rich gneiss, black–dark grey, fine grained, equigranular, thin quartzite interbeds, greater then 1200 feet thick, gradational contact with Hbg unit 145–170 Ma

Muscovite Granite (Klgr, Kmgs)–
Quartz, Muscovite, Feldspar rich granite, white coarse to medium grained, sill and dikes common, grades laterally into pegmatite dikes, 5–100 feet thick, 60–105 Ma.

Pegmatite (Jpeg)–
Quartz, biotite, feldspar rich granite, minor muscovite, white, coarse to fine grained, dikes, and sills common, 5–50 feet thick, 158–160 Ma.

Orocopia Schist (Os)–
Medium grained albite–epidote–amphibolite facies schist to coarse grained amphibolite facies schist, graywacke protolith. Unknown thickness >170 Ma. Not exposed at Mesquite Mine

Source: Newmont Mining Corporation

Mesquite Mine Expansion
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Figure 2-2

Tectono-Stratigraphic Column of the Chocolate Mountains and Mesquite Mine

Prepared by
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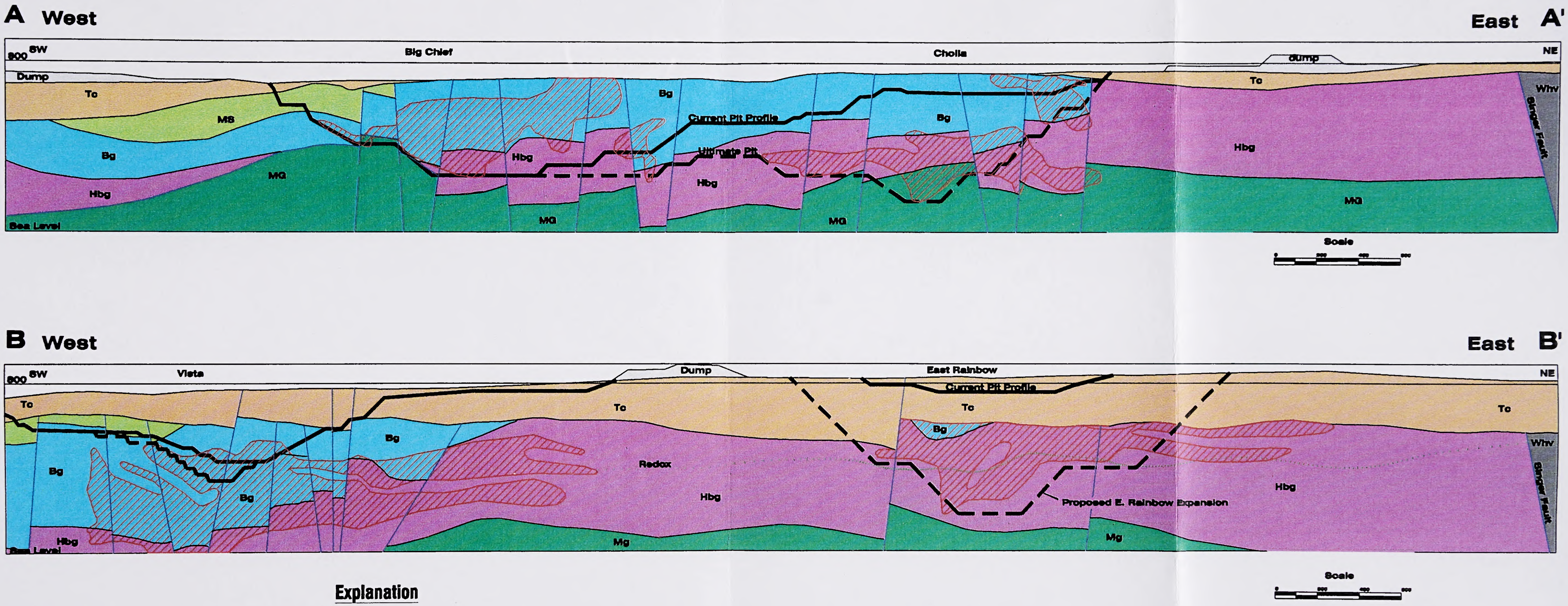


Explanation

STRATIGRAPHY

TERTIARY-QUATERNARY
- Mine Dumps & Leach Pads
- Tc Alluvium
- Tqv Quechan Volcanics

CRETACEOUS
- Kmgs Muscovite Granite

MESOZOIC-JURASSIC
- Jpeg Pegmatite
- Jms MS- Muscovite Schist & Gneiss
- Jbg BG- Biotite Gneiss
- Jhbg HBG- Hornblende-Biotite Gneiss
- Jal Alaskite
- Jmg MG- Mafic Gneiss
- Mzi Mesozoic Intrusives
- Mzw Winterhaven Fm.

▨ Ore

Current Pit Profile

Proposed Pit Profile

Source: Newmont Mining Corporation

Mesquite Mine Expansion
Prepared for
Imperial County Planning and Building Department

Figure 2-3

Geologic Cross-Sections
Through the Mine Area

Prepared by
Baker Consultants, Inc.

BCI-fig2-3.dwg

Silt/Sand/Clay (Tsc/Tcg2) and (3) Mineralized Conglomerate (Tcm) (SMI, 1998a).

Cretaceous Muscovite Granite (Kmgs/Lgr) - A pale quartz, muscovite and feldspar-rich granite (leucogranite) commonly dissected by sills and dikes outcropping primarily in the North Half-Sections.

Jurassic schists and gneisses of the Chuckwalla Complex. These bedrock or basement rock units form the bottom and walls of the existing pits and are host to epithermal gold mineralization. The majority of the surface area of the pits is comprised of the following four units differentiated on the basis of their textural and mineralogic properties:

Jurassic Muscovite Schist and Gneiss (Jms) -Medium to light gray muscovite schists and gneisses containing tourmaline, amphibole, quartzofeldspathic and epidote-rich zones depending on the degree of metamorphism locally present.

Jurassic Biotite Gneiss (BG) - A biotite (10-30%), quartz (70-90%) and feldspar-rich gneiss with weak layering and salt-and-pepper appearance developed from a protolith of impure feldspathic quartz arenite to clean quartz arenite.

Jurassic Hornblende Biotite Gneiss (HBG) - A biotite (30-40%), quartz (55-70%) and feldspar-rich augen gneiss containing imperfectly-shaped augen of quartz-feldspar, compositional layering of biotite and quartz-feldspar, hornblende crystal clusters retrograded to biotite and common chlorite alteration. The protolith for the HBG was volcaniclastic rock.

Jurassic Mafic Gneiss (MG) - A dark gray, fine grained biotite (60%), quartz (30-40%) and feldspar-rich gneiss with equigranular texture containing thin quartizite interbeds and minor disseminated pyrite. This is the lowest geologic unit encountered in the mine sequence.

2.5.2 Acid-Base Accounting Characteristics

Static acid-base accounting (ABA) tests are performed to identify rock types that are potentially capable of generating acidic conditions upon oxidation. In pit lake characterization studies, both static ABA and dynamic (kinetic) tests (discussed in Section 2.5.4) are used to predict the chemistry of the fluids that will be released from pit wall or backfill materials and flow into the future mine pit lake. These fluids may contribute acid to the lake waters or they may have a net-neutralizing effect. In either case, dissolved metals may be released from wall rock and/or backfill materials, contributing to pit lake water quality.

Over the years, a variety of analytical methods have been used for ABA determination at mine sites. These methods typically rely on quantification of the relative sulfide and carbonate contents of wall rock and overburden materials. The potential to generate acid, referred to as the acid generating potential (AGP), is generally related to the oxidation of pyrite which releases sulfate and hydrogen ions when saturated. The AGP is based on the amount of sulfide sulfur in the rock material as determined from a series of chemical extractions which selectively extract and differentiate between total sulfur, sulfate sulfur, sulfide sulfur and organic sulfur (Sobek et al., 1978). The potential to neutralize acid, referred to as the acid neutralization potential (ANP), is generally related to the capacity of the material to consume (or neutralize) acid as a result of carbonate and silicate dissolution. The ANP is typically determined from titrations with hydrochloric acid and sodium hydroxide (Lapakko, 1993) or combustion of carbonate minerals in a high temperature furnace.

The AGP of a rock material assumes that pyrite is the major acid-generating mineral and is calculated as follows:

$$AGP = 31.2\ S$$

where S equals the weight percent of sulfide sulfur in the rock and 31.2 is a constant representing the molecular weight of calcium carbonate divided by the atomic weight of sulfur

and multiplied by 10 to convert percent to parts per thousand. The units of AGP are tons of $CaCO_3$ per kiloton of rock (parts per thousand).

Similarly, the ANP of a rock material can be calculated as follows:

$$ANP = 83.3\ C$$

where C equals the weight percent of carbonate carbon and 83.3 is a constant representing the molecular weight of $CaCO_3$ divided by the atomic weight of carbon and multiplied by 10 to convert percent to parts per thousand. ANP is also expressed in units of tons of $CaCO_3$ per kiloton of rock (parts per thousand).

The capacity of a rock material to counteract the effects of sulfide oxidation is called its net neutralization potential (NNP) which is calculated as the difference between ANP and AGP:

$$NNP = ANP - AGP$$

It is generally accepted among regulators that wall rock or overburden materials with NNP values of less than -20 tons $CaCO_3$ per kiloton rock are potentially acid-generating, whereas those with NNP values of greater than +20 tons $CaCO_3$ per kiloton rock are clearly net neutralizing (Lapakko, 1993; USEPA, 1994). Materials characterized in the range of NNP between -20 and +20 (sometimes called the zone of uncertainty) require further kinetic testing to determine their site-specific potential for acid generation (USBLM, 1996). Tests commonly applied for this purpose are humidity cell tests and dynamic column tests.

Several sources of data are available for ABA characterization of rock materials collected from the Mesquite Mine. These data, which have consistently indicated that Mesquite wall rocks and overburden materials are generally net neutralizing, are discussed below.

Environmental Impact Report/Environmental Assessment (EIR/EA) for the VCR Project

Samples of ore and overburden collected from above and below the oxidized zone at the original Mesquite Pit were submitted for ABA characterization by ESI (1987) as part of the EIR/EA conducted for the VCR Project. Although the total number of samples analyzed, analytical methods used and rock types tested are not provided in ESI (1987), the results of the ABA testing indicated that the materials were alkaline in nature and generally net neutralizing (Table 5.1 in ESI, 1987). The mean pH, AGP, ANP and NNP values reported were 7.9, 14.4 63.6 and 49.2 tons $CaCO_3$ per kiloton rock, respectively.

Mesquite Mine Metallurgical Laboratory

Between 1992 and 1995, ABA testing of waste rock and ore from the Big Chief and Vista Pits was performed by the Mesquite Mine metallurgical laboratory. Results from this period of testing are provided in Appendix C of SMI (1998). Again information on methods of analysis and rock types was not documented, but the ABA determinations indicated that the materials tested were slightly alkaline and generally net neutralizing in composition. AGP and ANP values ranged from 0 to 56 tons $CaCO_3$ per kiloton and 9.2 to 233 tons $CaCO_3$ per kiloton, respectively. Total sulfur content was generally low, ranging from 0 to 1.2 percent.

During the last two years, additional ABA determinations were performed on representative rock types collected from the Rainbow Pit and from the North Half-Sections (Sections 5 and 6). Eighteen core samples and 13 pulp samples obtained from exploration boreholes drilled as part of the Rainbow Pit Expansion of the Mesquite Mine were submitted by SMI for ABA testing by Energy Laboratories, Inc. of Casper, Wyoming (SMI, 1998b). The rock types that were selected for analysis were those that were expected to be exposed in the Rainbow Pit: units Tsc, Tcg, Tcm of the Tertiary conglomerate, and units HBG, MG, and BG of the Jurassic gneiss. Additional ABA testing was performed in the spring of 1999, when 111 rock samples were collected during exploration drilling in the North Half-Sections. The latter samples were submitted to American Assay Laboratories of Sparks, Nevada for ABA analysis

and represented the following rock types: Quaternary alluvium (Qal), muscovite granite or leucogranite (Lgr) and the Jurassic gneiss units HBG and MG. The results from the ABA determinations performed in the Rainbow Pit and North Half-Sections are summarized in Table 2.8 and tabulated in Tables D.1 and D.2, respectively, of Appendix D.

Comparison of the two data sets presented in Table 2.8 indicates that the rock types encountered in the Rainbow and North Half-Sections are typically net neutralizing with positive NNP values. However, there are also distinct differences evident in the ABA characteristics of the rocks present in the two areas, as described below. Within the Rainbow Pit, ABA results for Tsc, Tcg and Tcm are very similar (with carbonate contents ranging from 0.6 to 10.8 percent and sulfide sulfur below detection). This suggests that from an ABA viewpoint these materials can be grouped together into one (Tc) group displaying NNP values of 30-40 tons $CaCO_3$ per kiloton of rock. Tc materials are not expected to be acid generating (AGP values are close to zero), and in general, they are only exposed high on the pit walls above the current water table. If used as backfill for the mine pits, Tc materials will likely become saturated by rising ground water levels but will remain overall net-neutralizing. No samples of Tertiary conglomerate were collected from the North Half-Sections.

Comparison of the ABA characteristics exhibited by BG, HBG and MG materials within the Rainbow Pit (Table 2.8) indicates that the BG and HBG rock types can be grouped into one ABA group. The mean NNP values computed for these rock types are quite similar (11 and 9.7 tons $CaCO_3$ per kiloton of rock), suggesting that again these materials are generally net neutralizing. However, the BG/HBG group has less neutralizing capability than the Tc group. The MG rock samples collected from the Rainbow Pit contain significantly more carbonate than the BG/HBG group, resulting in a significantly greater neutralizing potential (mean NNP equal to 69 tons $CaCO_3$ per kiloton of rock).

No ABA data from the North Half-Sections are available for the BG rock type. However, comparison of the ABA characteristics of HBG and MG materials collected from the Rainbow

Pit and North Half-Sections points out interesting contrasts between the two areas. HBG samples collected from the North Half-Sections have significantly lower carbonate and sulfide contents (means of 0.055 %C and 0.001 %S) than HBG samples collected from the Rainbow Pit (means of 0.178 %C and 0.05 %S), yet the two sets of HBG display similar overall neutralizing potential (mean NNP of Rainbow HBG is 9.7 tons $CaCO_3$ per kiloton of rock and mean NNP of HBG in the North Half-Sections is 5 tons $CaCO_3$ per kiloton of rock). Similarly, samples of the MG rock type collected from the North Half-Sections contain significantly less carbonate and sulfide sulfur (North Half-Section means are 0.204 %C and 0.002 %S compared to Rainbow means of 1.128 %C and 0.20 %S). However, in this case, Rainbow MG samples have higher NNP values on average (69 tons $CaCO_3$ per kiloton of rock) than MG samples collected from the North Half-Sections (17 tons $CaCO_3$ per kiloton of rock).

Due to the significant differences observed in carbonate and sulfide contents of HBG and MG rocks collected from the Rainbow and North Half-Section areas, it is not reasonable to infer the ABA characteristics of HBG or MG materials uniformly across the mine site. It should also be noted that only the MG rock type encountered in the Rainbow Pit is clearly net neutralizing according to the definition of $NNP > +20$ tons $CaCO_3$ per kiloton of rock, whereas the other gneissic materials from both locations fall within the NNP range of 0-20 tons $CaCO_3$ per kiloton of rock, and therefore exhibit greater uncertainty in their neutralizing capacity.

2.5.3 Whole Rock Analysis

Whole rock analyses have been performed on rock samples collected from the VCR Project Area (ESI, 1987), Rainbow Pit (SMI, 1998) and the North Half-Sections (Newmont, 1999). The primary purpose of these analyses is to assay for gold and characterize metals and other chemical constituents associated with gold mineralization. However, in recent years, whole rock analyses are increasingly being used to establish the relative abundance of metals in mine waste rocks in order to identify lithologies that can potentially leach solutes into developing pit

lakes and ground water. The most common method used for analysis is EPA Method 3050 (USEPA, 1990a).

Naturally-occurring concentrations of selected metals in samples of Mesquite Mine ore and overburden analyzed for the VCR Project were reported to be relatively low and well below their respective regulatory standards (Table 5.1 in ESI, 1987). Whole rock analyses of Tsc, Tcg, Tcm, BG, HBG and MG rocks from the Rainbow Pit (SMI, 1998b) indicated that the chemical composition of the conglomeratic units was typical of mean concentrations of chemical constituents detected in surficial soils, sandstones and shales. However, the gneisses contained elevated concentrations of arsenic, and occasionally selenium and silver, compared to average values observed in diabase and igneous rocks in the earth's crust.

A complete tabulation of results from whole rock analyses performed on rock samples from the Rainbow Pit and North Half-Sections is provided in Tables D.3 (Rainbow) and D.4 (North Half-Sections) of Appendix D. The chemical composition of the major rock types encountered at these two locations is summarized in Table 2.9. Comparison of the geometric means and ranges of concentrations presented in the table indicates that concentrations of bismuth, cadmium, chromium, manganese, molybdenum, thallium and titanium are typically higher in the North Half-Sections. This is particularly true for bismuth, cadmium, thallium and titanium which are more than one order of magnitude higher. Mean concentrations of magnesium and arsenic tend to be higher in samples collected from the Rainbow Pit.

2.5.4 Predicted Release of Solutes from Backfill

Kinetic testing of rock samples by the column or humidity cell test method are commonly applied at mine sites to provide preliminary estimates of the chemical composition of fluids that may be released from the pores and fractures of pit wall rock, waste rock and backfill materials after extended exposure to the atmosphere. It should be noted that dissolution of certain metals is not dependent on the occurrence of acid rock drainage (ARD), and that certain metals are preferentially released by basic solution. At the Mesquite Mine, kinetic

testing was performed by SMI (1998b) on one sample each of HBG and MG rock collected from the Rainbow Pit.

The HBG and MG rock samples were obtained from below the redox boundary in borehole MRD-3366. The HBG sample was taken from fault gouge encountered in the interval 511-511.5 feet and the MG sample from a fracture zone encountered in the interval 568.7-570 feet. The samples were selected for kinetic testing based on their elevated total sulfur contents (2.22 percent for the HBG and 1.5 percent for the MG) which were the highest observed in the Rainbow Pit, and consequently, were thought to provide a worst case estimate of chemical constituents that would be leached from these materials. The testing method applied was based on a modification of ASTM Method D5744-96 (ASTM, 1996) using a modified humidity cell container in the case of the HBG sample and a packed-column assembly in the case of the MG sample. The rock samples were initially inoculated with iron-oxidizing bacteria, *Thiobacillus ferrooxidans*, to accelerate the process of sulfide oxidation, and were subsequently subjected to alternating wetting and drying cycles for a period of 20 weeks. Leachate samples were collected at routine intervals for chemical analysis. A detailed discussion of the experimental procedures used for kinetic testing is provided in SMI (1998).

The results from the SMI kinetic tests are provided in Table D.5 of Appendix D. The pH A values measured in the HGB and MG leachates were slightly to moderately alkaline, ranging from 7.9 to 10.1. Neither sample proved to be acid generating and both exhibited moderately high buffering capacity as suggested by the relatively high concentrations of total alkalinity and low concentrations of total acidity measured. TDS concentrations (estimated by multiplying EC by 0.64) were initially elevated (212 mg/L for the MG sample and 554 mg/L for the HBG sample), but they decreased significantly over time (to 33 and 31 mg/L for the MG and HBG samples, respectively in Week 20). This suggests that significant leaching of solutes took place during the 20-week period. Concentrations of ammonium, nitrate/nitrite, phosphorus and sulfate in the leachates were low throughout the kinetic testing. Metal concentrations were also low except for aluminum released from both samples in Week 0 (one hour after startup of the kinetic tests) and antimony released from the MG sample in Week 0. The above

concentrations exceeded the primary MCL established for antimony and the secondary MCL for aluminum (Table 2.5).

Despite minor experimental difficulties encountered during the testing of the HBG sample (SMI, 1998), the results from both kinetic tests were used to provide preliminary estimates of the mass of solutes that might be released into the mine pits during the backfilled pit option. The relative mass of solutes predicted to be released from HBG and MG materials is presented in Table 2.10. Because data to estimate solute releases are limited to these two materials, the concentrations of solutes that are likely to be released into the mine pits from saturated backfill materials were based on the geometric mean (bedrock) concentrations indicated in the far right column of Table 2.10. Given the variability in chemical composition of rock types that could potentially be used as backfill (as indicated in the previous sections), the predicted concentrations contain a high degree of uncertainty (± one order of magnitude).

TABLE 2.1 CORRELATION OF HYDROSTRATIGRAPHIC UNITS WITH GEOLOGIC UNITS AND FORMATIONS

Age	Hydrostratigraphic Unit	Geologic Unit or Formation		
	Current Study	ESI (1987, 1993)	SMI (1998)	Current Study
Quaternary	Alluvium	Alluvium	Surficial deposits	Alluvium
	Recent	Younger		Undifferentiated (Qal)
		Intermediate		
	Older	Older		
Tertiary	Conglomerate Undifferentiated	Bear Canyon Conglomerate	Conglomerate and mineralized conglomerate (Tcg/Tcg1/Tcm)	Conglomerate interbedded with silt, clay and basalt (Tc/Tqv)
	Clay	Silt/Sand/Clay (Tsc/Tcg2)		
Cretaceous				Muscovite granite/leucogranite (Kmgs/Lgr)
Jurassic				Pegmatite (Jpeg)
	Gneiss			Muscovite schist and gneiss (Jms)
	Biotite	Biotite gneiss	Biotite gneiss (BG)	Biotite gneiss (Jbg or BG)
	Hornblende	Undifferentiated gneiss	Hornblende biotite gneiss (HBG)	Hornblende biotite gneiss (Jhbg or HBG)
	Mafic		Mafic gneiss (MG)	Mafic gneiss (Jng or MG)
				Mesozoic/Jurassic Intrusives (Mzi/Jal)
				Winterhaven Formation (MZW)

TABLE 2.2 PIT LAKE WATER BALANCE SUMMARY

Pit Lake Name	Pumping Q_{pump} (gpm)	Direct Precipitation Q_{DP} (gpm)	Evaporation Q_E (gpm)	Net Ground Water Inflow Q_{GW} (gpm)[1]
Big Chief	43	0.2	6.2	49
Rainbow	2	0.1	2.5	4.4
Vista				
East	7	0.1	2.5	9.4
West	0	0.1	2.8	2.7
Panhandle	0	0.4	10.9	11
Rubble Ridge	0	0.2	4.9	4.7
Vista Total	-	-	-	28

[1] Rounded to two significant digits.

$Q_{GW} = Q_{pump} + Q_E - Q_{DP}$

TABLE 2.3 STREAMTUBE ACCOUNTING SUMMARY

Streamtubes Delivering Water to Location:	Water [1] Required Q_{GW} (gpm)	Number of Streamtubes Counted	Streamtube Water [1] Delivery (gpm)
East Flow Net			
North Boundary Influx(550 ft)	38.4	12	38.4
Rainbow Pit Lake	- 4.4[2]	- 2	- 6.4
Vista East Lake	- 9.4	- 3	- 9.6
Vista West lake	- 2.7	- 1	- 3.2
Vista Panhandle Lake	- 11	- 3.5	- 11.2
Vista Rubble Ridge Lake	- 4.7	- 1.5	- 4.8
South Boundary (450 ft)	- 3.2	- 1	- 3.2
Balance	3.0	0	0
West Flow Net			
North Boundary Influx	60	8	60
Big Chief Pit Lake	- 49[2]	- 7	- 52.5
South Boundary (450 ft)	- 7.5	- 1	- 7.5
Balance	3.5	0	0

[1] Positive value represents influx to flow net; negative value represents removal (outflux) from flow net.

[2] From pit lake water balance.

TABLE 2.4 EXISTING LAKE WATER QUALITY

	Mean Concentration[1] (mg/L except where noted)			
Parameter	Big Chief	Vista West	Vista East	Rainbow
pH[2]	8.30	8.66	8.30	8.92
Specific Conductance[3]	2073	6580	2550	3250
Alkalinity (Total)[4]	262	266	258	334
Aluminum	< 0.031	< 0.031	0.034	0.122
Ammonia (as N)	< 0.01	< 0.01	< 0.01	< 0.01
Antimony	< 0.002	0.005	0.002	0.019
Arsenic	0.0081	0.012	0.0096	0.045
Barium	0.021	< 0.003	0.019	0.007
Beryllium	< 0.002	< 0.002	< 0.002	< 0.002
Bismuth	< 0.027	-	< 0.027	< 0.027
Boron	1.58	4.30	1.52	3.01
Cadmium	0.002	< 0.002	0.002	< 0.002
Calcium	44.3	57.6	40.7	12.6
Chloride	271	1110	327	447
Chromium	< 0.008	< 0.008	0.006	< 0.008
Cobalt	< 0.003	-	< 0.003	< 0.003
Copper	< 0.006	0.003	< 0.006	< 0.006
Cyanide (Total)	< 0.01	0.02	< 0.01	< 0.01
Cyanide (WAD)	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	1.0	2.3	1.5	3.5
Gallium	< 0.033	-	< 0.033	< 0.033
Iron	< 0.02	< 0.02	0.029	0.048
Lead	< 0.003	< 0.003	< 0.003	< 0.003
Lithium	0.062	-	0.063	0.168
Magnesium	26.3	56.3	19.1	11.6
Manganese	0.003	< 0.003	< 0.003	0.003
Mercury	<0.0002	< 0.0002	< 0.0002	< 0.0002
Molybdenum	0.043	0.156	0.038	0.167
Nickel	< 0.023	< 0.023	0.019	< 0.023
Nitrate/Nitrite (as N)	2.64	18.7	1.16	0.22
Orthophosphate (as P)	0.008	0.030	0.020	0.036
Potassium	10.4	-	8.5	10.8
Scandium	< 0.002	-	< 0.002	< 0.002
Selenium	0.020	0.083	0.010	0.022
Silica	19.9	19.6	19.0	22.7
Silver	< 0.007	< 0.007	< 0.007	< 0.007
Sodium	472	1441	482	732
Strontium	1.32	2.85	1.05	0.360
Sulfate	572	1750	600	731
Thallium	< 0.003	< 0.003	< 0.003	< 0.003
Tin	0.05	< 0.1	0.05	< 0.1

TABLE 2.4 EXISTING LAKE WATER QUALITY

Parameter	Mean Concentration[1] (mg/L except where noted)			
	Big Chief	Vista West	Vista East	Rainbow
Titanium	< 0.011	< 0.011	< 0.011	< 0.011
Total Dissolved Solids	1422	3630	1535	1992
Total Suspended Solids	7.5	147	8.4	20.8
Vanadium	< 0.007	< 0.006	< 0.007	< 0.007
Zinc	< 0.007	< 0.007	0.004	< 0.007

[1] The geometric mean was calculated for all constituents except pH where the arithmetic mean was used. Values below detection were calculated at one-half the detection limit.

[2] Standard units

[3] uS

[4] mg/L $CaCO_3$

TABLE 2.5 CALIFORNIA WATER QUALITY GOALS

Parameter	Primary MCL (a)	Secondary MCL (a)	Agricultural Water Quality Goal	Ambient Aquatic 4day- Average	Ambient Aquatic 1hr-Average
	(Units in mg/L except where noted)				
Aluminum	1	0.2	5	0.087	0.75
Ammonia (as N)	-	-	-	pH, temp dependent	pH, temp dependent
Antimony	0.006	-	-	0.03	0.088
Arsenic	0.05	-	0.1	0.19	0.36
Barium	1	-	-	-	-
Beryllium	0.004	-	0.1	-	-
Boron	-	-	0.70 / 0.75 (b)	-	-
Cadmium	0.005	-	0.01	0.0019 (c)	0.0091 (c)
Chloride	-	250	106	230	860
Chromium (Total)	0.05	-	-	-	-
Cobalt	-	-	0.05	-	-
Copper	1.3 (d)	1	0.2	0.023 (c)	0.037 (c)
Cyanide (Total)	0.2	-	-	0.0052	0.022
Fluoride	1.4 - 2.4 (e)	-	1	-	-
Iron	-	0.3	5	-	-
Lead	0.012 (d)	-	5	0.0062 (c)	0.16 (c)
Manganese	-	0.05	0.2	-	-
Mercury	0.002	-	-	0.000012 (f)	0.0021 (g)

Source: Marshack, 1998

(a) California Department of Health Services Maximum Contaminant Level (MCL)

(b) U.S. Environmental Protection Agency, Quality Criteria for Water, 1986 (May 1986) (The Gold Book) plus updates

(c) Based on hardness of 230 mg/L measured in Big Chief lake

(d) MCL includes this "Action level" to be exceeded in no more than 10 percent of samples at the tap

(e) MCL varies with air temperature

(f) Expressed as total recoverable

(g) Expressed as dissolved

(h) Expressed as NO_3

(i) Second value is the upper level recommended by the California Department of Health Services

TABLE 2.5 CALIFORNIA WATER QUALITY GOALS

Parameter	Primary MCL (a)	Secondary MCL (a)	Agricultural Water Quality Goal	Ambient Aquatic 4day- Average	Ambient Aquatic 1hr-Average
	(Units in mg/L except where noted)				
Molybdenum	-	-	0.01	-	-
Nickel	0.1	-	0.2	0.32 (c)	2.90 (c)
Nitrate (as N)	10 / 45 (h)	-	-	-	-
Nitrite (as N)	1	-	-	-	-
Nitrate plus Nitrite (as N)	10	-	-	-	-
pH	-	6.5-8.5 units	-	-	-
Selenium	0.02	-	0.02	-	-
Silver	-	0.1	-	0.00019 (g)	0.0014 (c)
Sulfate	-	250 / 500 (i)	-	-	-
Thallium	0.002	-	-	-	-
Total Dissolved Solids	-	500 / 1,000 (i)	450	-	-
Vanadium	-	-	0.1	-	-
Zinc	-	5	2	0.21 (c)	0.23 (c)

Source: Marshack, 1998

(a) California Department of Health Services Maximum Contaminant Level (MCL)

(b) U.S. Environmental Protection Agency, Quality Criteria for Water, 1986 (May 1986) (The Gold Book) plus updates

(c) Based on hardness of 230 mg/L measured in Big Chief lake

(d) MCL includes this "Action level" to be exceeded in no more than 10 percent of samples at the tap

(e) MCL varies with air temperature

(f) Expressed as total recoverable

(g) Expressed as dissolved

(h) Expressed as NO_3

(i) Second value is the upper level recommended by the California Department of Health Services

TABLE 2.6 SUMMARY OF SELECT GROUND WATER QUALITY DATA: VCR PROJECT AREA

Well Id	Date	pH (units)	SC(1) (uS)	TDS(2) (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)	Arsenic(3) (mg/L)	Chromium(3) (mg/L)	Iron(3) (mg/L)	Manganese(3) (mg/L)
WT-2	11/22/82	7.88	1,650	1,000	142	2.5	262	0.05	<0.01	0.80	0.08
	03/21/83	7.23	1,760	1,004	137	3.1	274	0.014	<0.01	0.56	0.03
	02/04/84	8.0	1,660	996	127	1.6	256	0.031	<0.01	0.03	<0.01
	05/04/84	8.4	1,800	997	146	1.32	251	-	-	-	-
	01/21/85	8.2	-	1,040	136	-	256	-	-	-	-
	10/25/85	7.99	1,630	969	140	1.71	260	0.003	<0.01	0.07	0.07
	12/12/85	8.36	1,561	938	110	1.58	266	0.026	<0.01	0.2	0.01
SM-63	11/22/82	7.61	1,560	960	125	1.3	280	0.01	<0.01	0.12	0.01
	03/21/83	7.14	1,650	992	104	3.3	274	0.014	<0.01	1.00	0.02
Singer	02/04/84	7.85	2,250	1,328	286	1.6	415	0.005	<0.01	0.82	0.06
GW-1	10/25/85	7.34	3,320	2,128	595	1.5	283	0.007	0.08	33	14
	12/12/85	7.52	3,105	2,032	486	1.09	168	0.037	0.14	22	1.7
	10/28/86	8.25	3,081	1,819	660	2.2	360	0.075	0.04	3.5	4.1
GW-2	10/25/85	7.35	3,230	1,960	876	1.7	325	0.001	<0.01	0.19	0.84
	12/12/85	7.75	3,485	1,992	863	1.02	330	0.007	<0.01	0.77	0.5
GW-3	10/25/85	7.92	1,221	869	129	1.3	297	0.002	<0.01	0.04	0.04
	12/12/85	8.23	1,346	890	134	1.81	292	0.017	<0.01	0.39	0.11
GW-4	10/23/86	8.14	2,027	1,270	309	2.0	342	0.009	0.03	0.04	0.14
MCR-80	01/18/85	7.28	3,306	1,800	609	-	425	-	-	6.8	-

Source: ESI, 1987

(1) SC=Specific conductance

(2) TDS=Total dissolved solids

(3) Concentrations presented as total (mg/L)

TABLE 2.7 EXISTING GROUND WATER QUALITY

	Concentration (mg/L except where noted)							
Parameter	GW-1	GW-2	GW-3	GW-4	GW-5	GW-6	GW-8A	GW-9
Date Collected	7/19/99	7/19/99	7/20/99	7/20/99	7/19/99	7/19/99	8/26/97	7/19/97
pH[1]	7.73	8.01	8.07	8.16	8.18	9.38	7.94	8.13
Specific Conductance[2]	2,760	3,000	1,330	1,890	1,750	2,060	-	-
Alkalinity (Total)[3]	140	64.3	239	224	198	44.7	212	248
Aluminum	0.082	0.121	< 0.037	0.051	< 0.037	< 0.037	< 0.037	< 0.037
Antimony	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	0.0015	< 0.003
Ammonia (as N)	0.25	0.15	< 0.01	< 0.01	< 0.01	< 0.01	-	-
Arsenic	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Barium	0.056	0.033	0.019	0.012	0.031	0.013	0.055	0.012
Beryllium	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Bismuth	-	-	-	-	-	-	< 0.027	< 0.027
Boron	1.67	1.71	1.17	1.27	1.15	1.61	1.12	1.18
Cadmium	< 0.0024	< 0.0024	< 0.0024	< 0.0024	< 0.0024	< 0.0024	< 0.0024	< 0.0024
Calcium	76.9	131	24.6	37.2	42.3	19.5	32.7	15.7
Chloride	633	846	137	288	297	479	336	177
Chromium	< 0.005	< 0.005	0.012	< 0.005	< 0.005	< 0.005	< 0.005	0.01
Cobalt	-	-	-	-	-	-	< 0.003	< 0.003
Copper	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Cyanide (Total)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cyanide (WAD)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	1.5	0.50	2.0	2.0	2.6	1.1	1.7	1.6
Gallium	-	-	-	-	-	-	< 0.033	< 0.033
Iron	0.03	< 0.02	< 0.02	0.03	< 0.02	< 0.02	< 0.02	< 0.02
Lead	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Lithium	0.050	0.12	0.055	0.054	0.061	0.087	0.055	0.073
Magnesium	11.1	5.08	5.23	10.6	8.34	9.1	6.69	6.09
Manganese	0.832	0.018	< 0.002	0.008	0.006	0.004	0.108	< 0.002
Mercury	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Molybdenum	0.069	0.033	0.026	0.062	0.058	0.027	0.061	0.036
Nickel	< 0.023	< 0.023	< 0.023	< 0.023	< 0.023	< 0.023	< 0.023	< 0.023
Nitrate/Nitrite (as N)	0.12	2.38	0.025	0.78	1.55	0.09	0.75	0.48
Orthophosphate (as P)	< 0.13	2.85	< 0.13	< 0.13	< 0.13	< 0.13	< 0.13	0.13
Potassium	4.6	5.8	3.4	4.8	6.6	5.4	5.1	3.8
Scandium	-	-	-	-	-	-	< 0.002	< 0.002
Selenium	< 0.048	< 0.048	< 0.048	< 0.048	< 0.048	< 0.048	< 0.048	< 0.048
Silica	25.5	17.3	29.3	26.6	24.3	5.84	23.6	27.1
Silver	< 0.006	0.007	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Sodium	557	567	260	372	416	435	417	305
Strontium	1.90	2.75	0.437	0.791	1.06	0.622	0.881	0.364
Sulfate	439	325	270	386	321	348	346	226
Thallium	< 0.003	< 0 .003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003

TABLE 2.7 EXISTING GROUND WATER QUALITY

Parameter	Concentrations (mg/L except where noted) GW-1	GW-2	GW-3	GW-4	GW-5	GW-6	GW-8A	GW-9
Date Collected	7/19/99	7/19/99	7/20/99	7/20/99	7/19/99	7/19/99	8/26/97	7/19/97
Tin	< 0.05	0.06	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Titanium	< 0.007	< 0.007	< 0.007	< 0.007	0.04	0.02	< 0.007	< 0.007
Total Dissolved Solids	1,630	1,740	801	1,180	1,050	1,160	1,290	866
Total Suspended Solids	6	615	3.6	16.2	58.8	339	2.5	1.4
Vanadium	0.012	< 0.007	0.045	< 0.007	0.017	0.009	< 0.007	< 0.007
Zinc	0.665	0.59	0.124	0.163	0.311	0.069	0.688	0.375

[1] Standard Units

[2] uS

[3] mg/L $CaCO_3$

TABLE 2.8 SUMMARY OF ACID-BASE ACCOUNTING CHARACTERISTICS

Rock Type	Parameter	Units	Rainbow Pit Min	Rainbow Pit Max	Rainbow Pit Mean[1]	North Half-Sections Min	North Half-Sections Max	North Half-Sections Mean[1]
Quaternary Alluvium	Carbonate	% $CaCO_3$	-	-	-	-	-	-
(Qal)	Carbonate	% C	-	-	-	0.010	0.579	0.067
	Sulfide	% S	-	-	-	< 0.001	0.006	0.001
	ANP	T $CaCO_3$/kT	-	-	-	1	48	6
	AGP	T $CaCO_3$/kT	-	-	-	0.03	0.19	0.04
	NNP	T $CaCO_3$/kT	-	-	-	1	48	5
Tertiary Sand/Silt/Clay	Carbonate	% $CaCO_3$	1.6	10.8	4.3	-	-	-
(Tsc)	Carbonate	% C	-	-	-	-	-	-
	Sulfide	% S	< 0.01	< 0.01	< 0.01	-	-	-
	ANP	T $CaCO_3$/kT	16	108	43	-	-	-
	AGP	T $CaCO_3$/kT	0.31	0.31	0.31	-	-	-
	NNP	T $CaCO_3$/kT	16	108	43	-	-	-
Tertiary Conglomerate	Carbonate	% $CaCO_3$	0.6	10.6	3.1	-	-	-
(Tcg)	Carbonate	% C	-	-	-	-	-	-
	Sulfide	% S	< 0.01	< 0.01	< 0.01	-	-	-
	ANP	T $CaCO_3$/kT	6	106	31	-	-	-
	AGP	T $CaCO_3$/kT	0.31	0.31	0.31	-	-	-
	NNP	T $CaCO_3$/kT	6	106	31	-	-	-
Tertiary Mineralized	Carbonate	% $CaCO_3$	1	5.7	3	-	-	-

TABLE 2.8 SUMMARY OF ACID-BASE ACCOUNTING CHARACTERISTICS

Rock Type	Parameter	Units	Rainbow Pit Min	Rainbow Pit Max	Rainbow Pit Mean[1]	North Half-Sections Min	North Half-Sections Max	North Half-Sections Mean[1]
Conglomerate (Tcm)	Carbonate	% C	-	-	-	-	-	-
	Sulfide	% S	< 0.01	< 0.01	< 0.01	-	-	-
	ANP	T $CaCO_3$/kT	10	57	30	-	-	-
	AGP	T $CaCO_3$/kT	0.31	0.31	0.31	-	-	-
	NNP	T $CaCO_3$/kT	10	57	30	-	-	-
Leocogranite (Lgr)	Carbonate	% $CaCO_3$	-	-	-	-	-	-
	Carbonate	% C	-	-	-	0.034	0.255	0.083
	Sulfide	% S	-	-	-	< 0.001	0.003	0.002
	ANP	T $CaCO_3$/kT	-	-	-	3	21	7
	AGP	T $CaCO_3$/kT	-	-	-	0.03	0.09	0.05
	NNP	T $CaCO_3$/kT	-	-	-	3	21	7
Jurassic Biotite Gneiss (BG)	Carbonate	% $CaCO_3$	0.7	4	1.2	-	-	-
	Carbonate	% C	-	-	-	-	-	-
	Sulfide	% S	< 0.01	0.16	0.02	-	-	-
	ANP	T $CaCO_3$/kT	7	40	12	-	-	-
	AGP	T $CaCO_3$/kT	0.31	5	0.73	-	-	-
	NNP	T $CaCO_3$/kT	5	40	11	-	-	-
Jurassic Hornblende Biotite Gneiss (HBG)	Carbonate	% $CaCO_3$	0.1	5.8	1.5	-	-	-
	Carbonate	% C	0.012	0.696	0.178	0.011	0.579	0.055

TABLE 2.8 SUMMARY OF ACID-BASE ACCOUNTING CHARACTERISTICS

Rock Type	Parameter	Units	Rainbow Pit			North Half-Sections		
			Min	Max	Mean[1]	Min	Max	Mean[1]
Jurassic Mafic Gneiss (MG)	Sulfide	% S	< 0.01	1.38	0.05	< 0.001	0.017	0.001
	ANP	T $CaCO_3$/kT	1	58	15	1	48	5
	AGP	T $CaCO_3$/kT	0.31	43	1.5	0.03	0.53	0.04
	NNP	T $CaCO_3$/kT	1	47	9.7	1	48	5
	Carbonate	% $CaCO_3$	5.2	25.5	9.4	-	-	-
	Carbonate	% C	0.624	3.060	1.128	0.011	0.817	0.204
	Sulfide	% S	< 0.01	2.05	0.20	< 0.001	0.069	0.002
	ANP	T $CaCO_3$/kT	52	255	94	1	68	17
	AGP	T $CaCO_3$/kT	0.31	64	6.3	0.03	2.15	0.05
	NNP	T $CaCO_3$/kT	34	239	69	1	68	17

[1] Geometric mean

Values below detection were calculated at the detection limit

TABLE 2.9 WHOLE ROCK ANALYSIS SUMMARY

Parameter	Rainbow Pit (mg/kg)			North Half-Sections (mg/kg)		
	Min	Max	Mean[1]	Min	Max	Mean[1]
Aluminum	1,260	95,500	9,640	1,800	31,500	9,540
Antimony	< 0.05	1.3	0.12	-	-	-
Arsenic	3.8	137	18.0	2	92	9.87
Barium	2.6	206	40.1	10	357	80.0
Beryllium	0.05	0.7	0.28	-	-	-
Bismuth	< 0.05	0.25	0.076	< 3	7	3.19
Boron	< 0.55	6.15	2.41	< 3	14	4.46
Cadmium	< 0.05	0.15	0.065	0.2	1.7	0.43
Calcium	1,190	480,000	11900	900	53,100	14,800
Chromium	< 2.25	23.4	8.23	6	145	20.2
Cobalt	0.55	24.2	5.64	2	18	7.84
Copper	7.5	132	21.6	5	93	22.0
Iron	3,720	42,700	14900	6,200	47,600	25,000
Lanthanum	-	-	-	2	60	15.2
Lead	< 0.75	10.8	4.06	< 3	20	4.44
Lithium	1.3	14.4	5.42	-	-	-
Magnesium	460	16,300	3380	400	14,500	570
Manganese	11.8	495	181	111	1,051	419
Mercury	< 0.05	0.2	0.062	< 0.01	0.27	0.046
Molybdenum	< 0.1	5.8	0.55	< 1	13	1.76
Nickel	< 1.05	29.1	6.64	2	33	11.6
Phosphorus	210	1,070	485	40	1,850	520
Potassium	300	8,000	1990	1,000	6,800	2,500
Selenium	0.05	1.6	0.21	-	-	-
Silica	< 89	1790	204	-	-	-
Silver	< 0.05	1.45	0.22	-	-	-
Sodium	180	2,240	684	200	3,200	600
Strontium	11.8	84.8	47.5	9	201	44.6
Thallium	< 0.05	0.25	0.079	< 2	52	6.53
Tin	< 0.05	0.6	0.18	-	-	-
Titanium	< 0.75	374	24.4	100	1,400	200
Vanadium	27.2	12.8	-	< 6	71	31.7
Zinc	151	30.6	-	12	214	38.6

[1] Geometric mean

Values below detection were calculated at the detection limit

TABLE 2.10 ESTIMATED MASS OF SOLUTES RELEASED FROM BACKFILL

Parameter	Mass Released Mafic Gneiss (mg solute/ kg rock)	Mass Released Hornblende Biotite Gneiss (mg solute/ kg rock)	Mass Released Bedrock (Geometric Mean) (mg solute/ kg rock)
Aluminum	0.337	0.252	0.291
Ammonium as N	1.12	1.30	1.21
Antimony	0.061	0.039	0.049
Arsenic	0.126	0.156	0.141
Barium	0.018	0.015	0.016
Beryllium	0.003	0.003	0.003
Boron	0.332	0.288	0.309
Cadmium	0.0009	0.001	0.001
Calcium	37.6	34.6	36.1
Carbonate	1060	428	674
Chloride	21.1	21.5	21.3
Chromium	0.002	0.003	0.002
Cobalt	0.009	0.010	0.009
Copper	0.070	0.045	0.056
Hydrogen	14.7	4.24	7.890
Iron	0.201	0.198	0.199
Lead	0.003	0.051	0.013
Lithium	0.072	2.62	0.433
Magnesium	2.97	0.009	0.163
Manganese	0.007	0.001	0.003
Mercury	0.001	0.014	0.004
Molybdenum	0.079	0.002	0.014
Nickel	0.014	13.6	0.442
Nitrate/Nitrite as N	1.82	1.56	1.68
Phosphorus (Total)	1.52	1.51	1.52
Potassium	41.2	0.002	0.320
Selenium	0.017	0.057	0.031
Silica	65.1	26.9	41.9
Silver	0.053	0.040	0.046
Sodium	367	121	210
Sulfate	98.9	49.0	69.6
Thallium	0.002	0.002	0.002
Tin	0.009	0.010	0.009
Zinc	2.02	2.26	2.14

3.0

EVALUATION OF OPEN PIT OPTION

3.1 OPTION DESCRIPTION

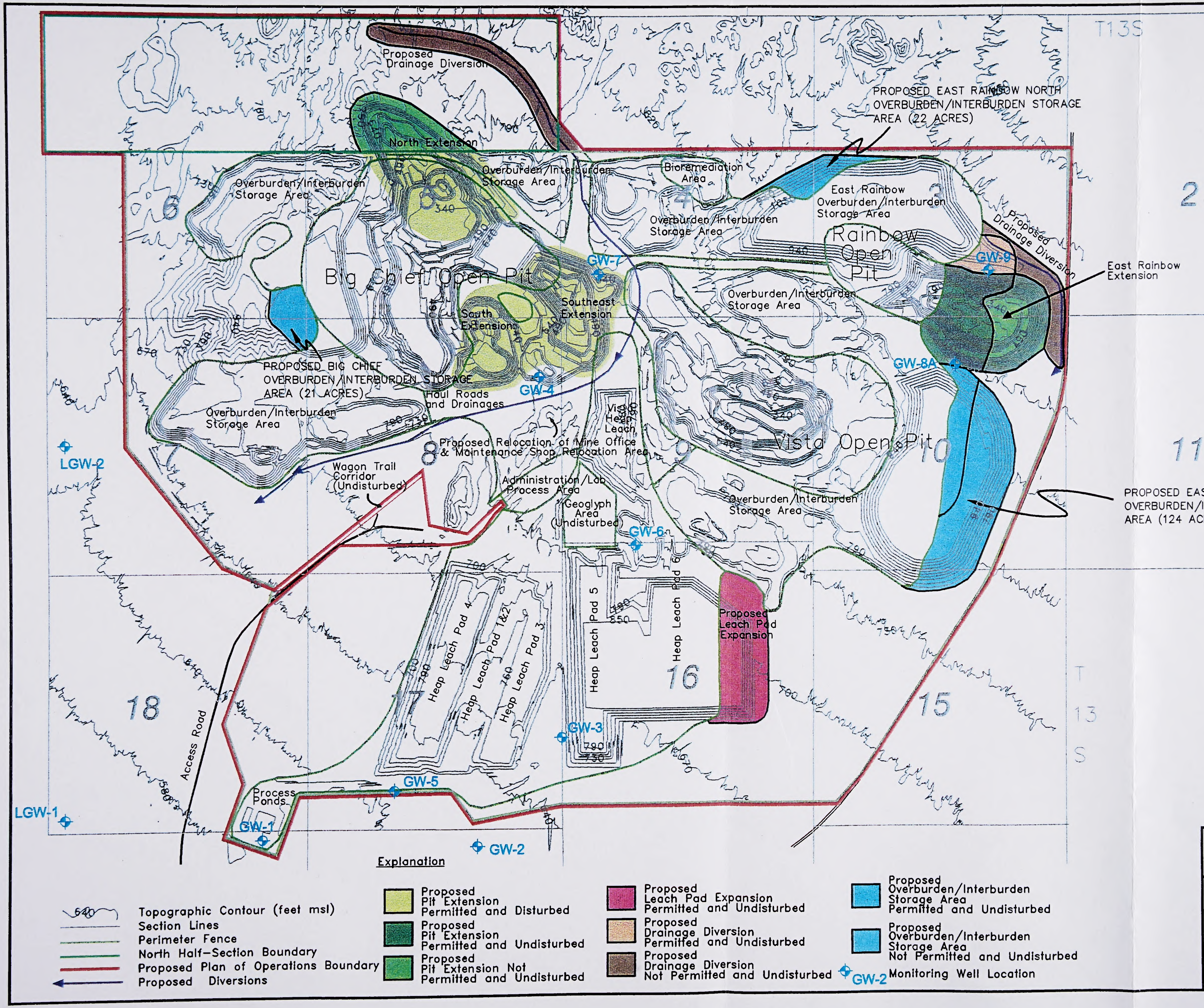
The out-of-pit OISA or open pit option consists of the expansion of the Big Chief and East Rainbow mine pits with removal of excavated waste rock to new or existing OISAs outside of the pit perimeters. In addition, the option includes expansion or movement of several other facilities. The expansion of the Big Chief Pit will occur in three areas: the North, South and Southeast Extensions (Figure 3-1).

The North Extension will project into Section 5 of the North Half-Sections, on the north side of the existing Big Chief Pit. The North and Southeast Extensions will require the re-routing of the northern storm water diversion ditch that diverts surface runoff from the mountains around the northern and eastern portion of the Big Chief Pit.

The North Extension will be approximately 570 feet deep at its maximum depth (mine floor elevation of 220 feet msl) (Figure 3-1). Dewatering will be accomplished primarily via sumps with occasional use of shallow wells as needed to control seepage and provide slope control. Under this option, the pit will remain open at its maximum depth. Waste rock will be moved to existing and new OISAs located to the west and south of the Big Chief Pit.

The South and Southeast Extensions (Figure 3-1) require closure and removal of part of the Vista heap leach pad, as well as the relocation of the mine office and maintenance shop and other facilities that lie within the proposed perimeters of the pits. The pits will attain maximum depths of 330 feet (400 feet msl mine floor elevation) and 450 feet (280 feet msl) in the south and southeast, respectively.

The pits will remain open at these depths after mining. Waste rock removed during mining will be stored in existing or new OISAs. The perimeters of all planned extensions of the Big Chief Pit will be bermed to prevent storm water runon (runoff from areas outside of the pit).


Proposed Drainage Diversion
North Extension
Overburden/Interburden Storage Area
Bioremediation Area
PROPOSED EAST RAINBOW NORTH OVERBURDEN/INTERBURDEN STORAGE AREA (22 ACRES)
East Rainbow Overburden/Interburden Storage Area
Rainbow Open Pit
Proposed Drainage Diversion
East Rainbow Extension
Big Chief Open Pit
Southeast Extension
South Extensions
GW-7
GW-9
GW-8A
GW-4
GW-6
GW-3
GW-5
GW-1
GW-2
LGW-1
LGW-2
PROPOSED BIG CHIEF OVERBURDEN/INTERBURDEN STORAGE AREA (21 ACRES)
Haul Roads and Drainages
Vista Heap Leach
Proposed Relocation of Mine Office & Maintenance Shop Relocation Area
Wagon Trail Corridor (Undisturbed)
Administration/Lab Process Area
Geoglyph Area (Undisturbed)
Vista Open Pit
PROPOSED EAST RAINBOW SOUTH OVERBURDEN/INTERBURDEN STORAGE AREA (124 ACRES)
Heap Leach Pad 4
Heap Leach Pad 1&2
Heap Leach Pad 3
Heap Leach Pad 5
Heap Leach Pad 6
Proposed Leach Pad Expansion
Process Ponds
Access Road
T13S
T 13 S
2
3
4
6
8
9
10
11
15
16
17
18
N
SCALE IN FEET
1000'
0
2000'
Source: Newmont Mining Corporation
Explanation
Topographic Contour (feet msl)
Section Lines
Perimeter Fence
North Half-Section Boundary
Proposed Plan of Operations Boundary
Proposed Diversions
Proposed Pit Extension Permitted and Disturbed
Proposed Pit Extension Permitted and Undisturbed
Proposed Pit Extension Not Permitted and Undisturbed
Proposed Leach Pad Expansion Permitted and Undisturbed
Proposed Drainage Diversion Permitted and Undisturbed
Proposed Drainage Diversion Not Permitted and Undisturbed
Proposed Overburden/Interburden Storage Area Permitted and Undisturbed
Proposed Overburden/Interburden Storage Area Not Permitted and Undisturbed
GW-2 Monitoring Well Location

Mesquite Mine Expansion
Prepared for
Imperial County Planning and Building Department

Figure 3-1

Out-of-Pit Overburden/Interburden Storage Area (Open Pit) Option

Prepared by
Baker Consultants, Inc.

BCIfig3-1.dwg

The proposed East Rainbow Extension lies southeast of the existing Rainbow Pit and west of Highway 78 (Figure 3-1). The ultimate pit will be 570 feet deep, completed to a final mine floor elevation of 280 feet msl. The waste rock removed from the pit may be used to backfill the Rainbow Pit and the remainder will be stored in the proposed North Rainbow and East Rainbow South OISAs. Ground water will be dewatered primarily via sumps and will be used for road watering and dust control. The pit will be bermed to prevent storm runon to the pit. The berm will be raised on the east side to reduce visual impacts from Highway 78. The pit will not receive any waste rock backfill under this option and will remain open at final depth.

The Vista Pit will not be expanded under this option but will be mined to an elevation of 220 feet msl under existing permits before the end of the year 2000. The pit will be backfilled to an elevation of approximately 310 feet at its eastern end and to an elevation of approximately 700 feet in the Panhandle area. The Vista Pit will remain open after the completion of mining according to the proposed mine Reclamation Plan (SMI, 1999).

Run-of-mine ore will be deposited on the extension to the existing Number 6 heap leach pad. No runoff or seepage to ground water is expected from the heap leach pad because heap leach facilities at the Mesquite Mine are lined for control and collection of the solutions that are contained within the process circuit.

3.2 CONDITIONS DURING MINING

3.2.1 Hydrologic Conditions

During mining, surface water drainage within the mine will be controlled and directed to in-pit sumps for removal along with ground water as part of dewatering and haul road watering operations. Little runoff is expected to occur within the mine pits, with the exception of runoff from roads and other compacted areas. No runon is expected due to the implementation of berming and runoff control measures. As discussed in Section 2.2, infiltration into benches and other pit surface is expected to be limited, resulting in a negligible amount of ground water

recharge within the pits. The OISAs are expected to produce no runoff during mining due to the rough surfaces on the exposed toes and slopes and associated low moisture content. Therefore, no ground water recharge is expected to occur from these facilities during mining.

Existing storm water diversion structures north of the mine property re-route storm flows from the slopes of the Chocolate Mountains. These will be modified as necessary to accommodate the new pit perimeters and OISAs.

Small pit lakes will form during mining and sumps will be utilized as needed for dewatering of the mine pits. Assuming that the surface areas of the sumps are kept small, evaporation losses will be relatively minor. However, most of the water removed from the sumps is used for dust control on roads where it will be lost by evaporation from the road surface. It is assumed that all dewatering water will be lost to evaporation either from pit lake surfaces or following controlled road watering. Therefore, none will be available for recharge to ground water.

During mining, ground water conditions will be dominated by the dewatering of the open pits in the active areas of the mine site. Pit dewatering was simulated by applying a hypothetical wellfield containing six wells arranged in a circle to represent the maximum extent of each mine pit. Ground water levels within the circle were lowered to the planned pit floor elevation (maximum depth) over a five year period by analytical solution of the model using superposition of wells.

The maximum dewatering rates that will be required to achieve the target drawdowns are reported in Table 3.1. Dewatering rates required for drawdown of the Big Chief North, Big Chief South, Big Chief Southeast, East Rainbow and Vista Pits to their final bottom elevations are predicted to be 100, 35, 65, 65 and 55 gpm, respectively.

3.2.2 Water Quality

As discussed in the previous section, surface water diversions and pit dewatering activities will control lake formation in the mine pits. However, water may accumulate for short periods in the sumps prior to being redistributed as makeup water to the leach pads or used for road dust suppression. Depending on residence time in the sumps, the chemical composition of the water collected is expected to vary between that monitored currently in ground water adjacent to the pits (Table 2.7) and that observed to date in the pit lakes (Table 2.4).

3.3 POST-MINING CONDITIONS

3.3.1 Hydrologic Conditions

Formation of Pit Lakes

At the end of mining (end of year 2006), pit dewatering and application of water to haul roads will cease and ground water will be allowed to flow into the mine pits unchecked. Ground water inflows will accumulate leading to the formation of five shallow lakes: Big Chief North, Big Chief South, Big Chief Southeast, East Rainbow and Vista. The rates of ground water inflow to the lakes during the initial stages of ground water recovery and lake development are assumed to be equal to the maximum rates required to dewater the pits to their bottom elevations (Table 3.1).

Ground water recovery was simulated using a simple analytical solution approach in which the elevation of water within the pit lakes was calculated. The analytical solution for drawdown in a large diameter well having well-bore storage was employed to represent water level rise in the developing pit lakes (Papadopulos and Cooper, 1967). This solution represents flow to a well where part of the water pumped from the well is from the aquifer and part of the pumped water comes from storage inside the well casing. The solution assumes that the well fully penetrates the aquifer, that drawdown inside and immediately outside of the well are

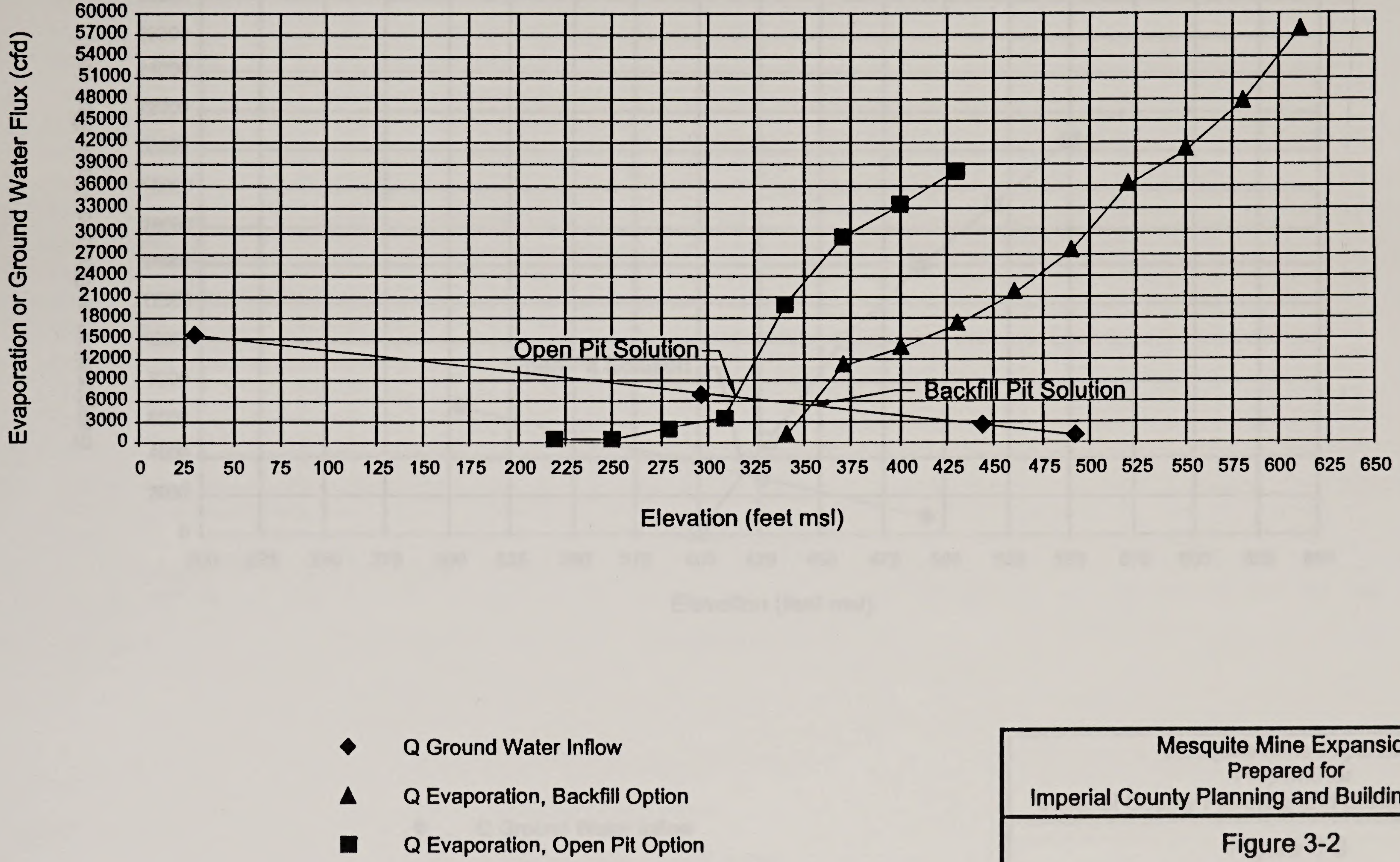
equal, and that drawdown is zero at an infinite distance from the well. It also assumes that the aquifer is homogeneous, isotropic, confined and of infinite extent, that flow is transient and that the pumping rate is constant. In this application, the well radius represents the average radius of the filling pit lake and the well-bore storage represents pit lake storage.

The analytical solution was applied to each pit to represent formation of the pit lakes and tailored to match conditions at each location. The ground water drawdown versus time curve for a large diameter well pumped at the average dewatering rate was calculated for each pit and the inverse of the curve was assumed to represent the corresponding recovery curve for each pit.

Without constraint, the analytical solution described above would allow lake elevations to rise significantly and unrealistically. Therefore, the competing process of evaporation from the lake surface was applied to control the elevations to which the lake surfaces would rise. The evaporation loss predicted for any elevation of the lake surface can be readily calculated from the area versus elevation relationship unique to each pit which can be determined directly from the topographic contours of each pit (Figure 3-1). Evaporation loss (flux Q_E) reported in units of cubic feet per day can be calculated as follows:

$$Q_E \quad = \text{(Lake Area x 6.67 ft/yr)/ 365.25 days/yr}$$

Proceeding with the analysis, Q_E values calculated for selected elevations in each pit can be plotted on a graph together with drawdowns calculated by the large diameter well solution for a range of pumping or Q_{GW} rates (Figures 3-2 - 3-6). The hypothetical pumping rates (Q_{GW} rates) represent the ground water inflow rates corresponding with specific lake surface elevations. The point at which the two curves intersect represents the elevation at which the ground water volumetric inflow rate, Q_{GW} , just matches the rate of volumetric evaporation loss, Q_E. That elevation, therefore, corresponds with the elevation to which the lake surface is



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Prepared for
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Figure 3-2

Lake Evaporation and Ground Water Flux Versus Elevation: Big Chief North

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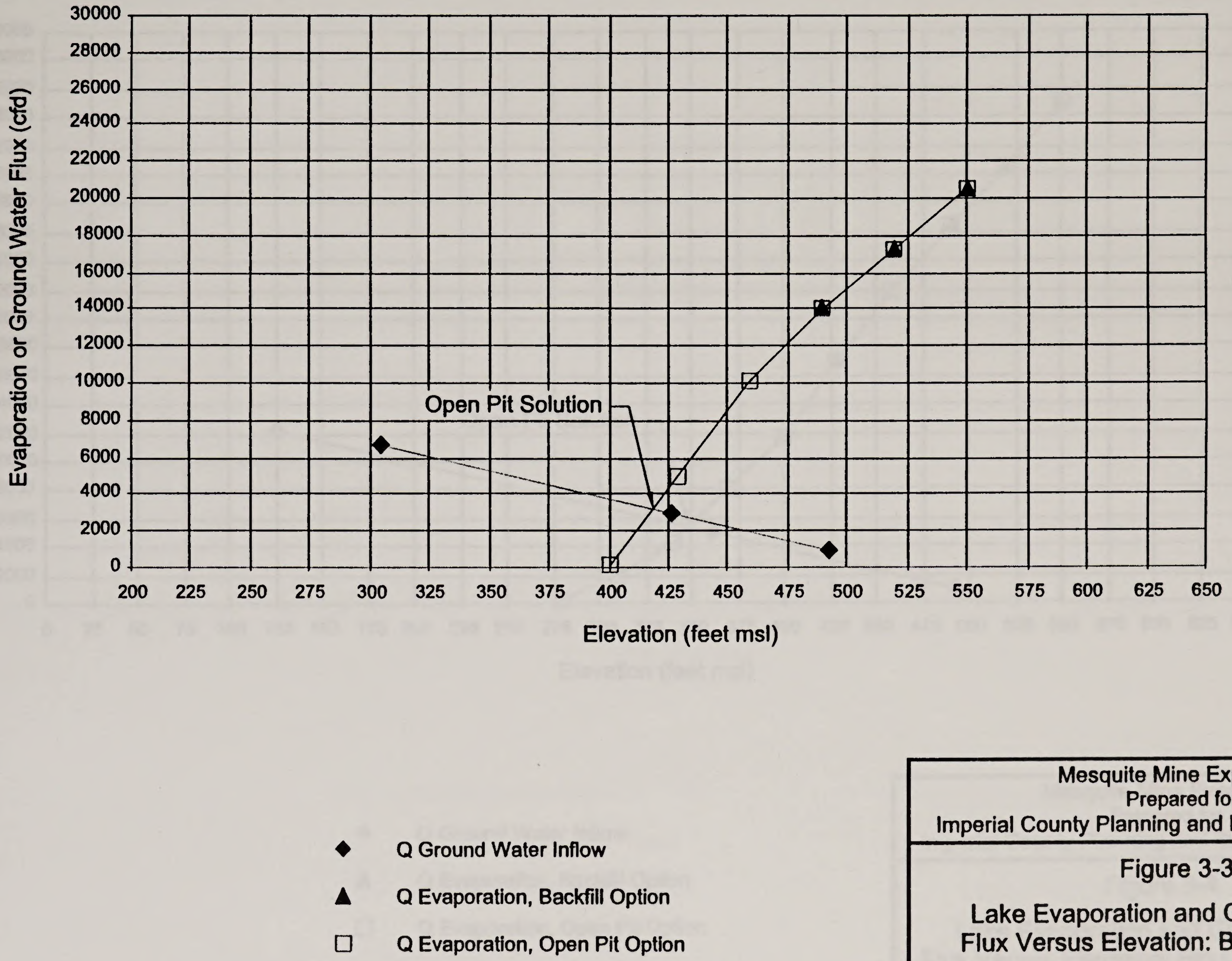

Mesquite Mine Expansion
Prepared for
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Figure 3-3

Lake Evaporation and Ground Water Flux Versus Elevation: Big Chief South

Prepared by
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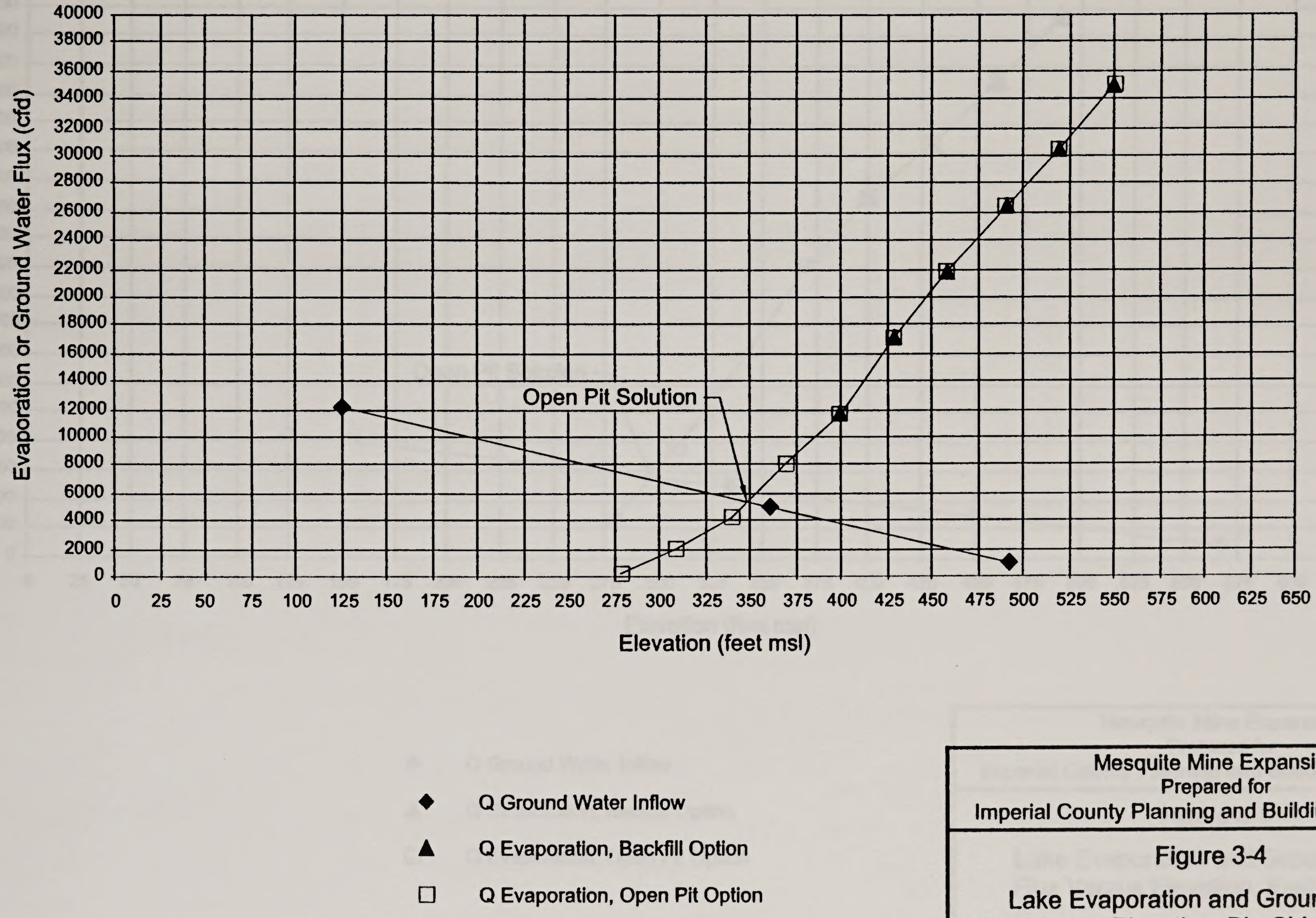
BCI-fig3-3.dwg



Mesquite Mine Expansion
Prepared for
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Figure 3-4

Lake Evaporation and Ground Water Flux Versus Elevation: Big Chief Southeast

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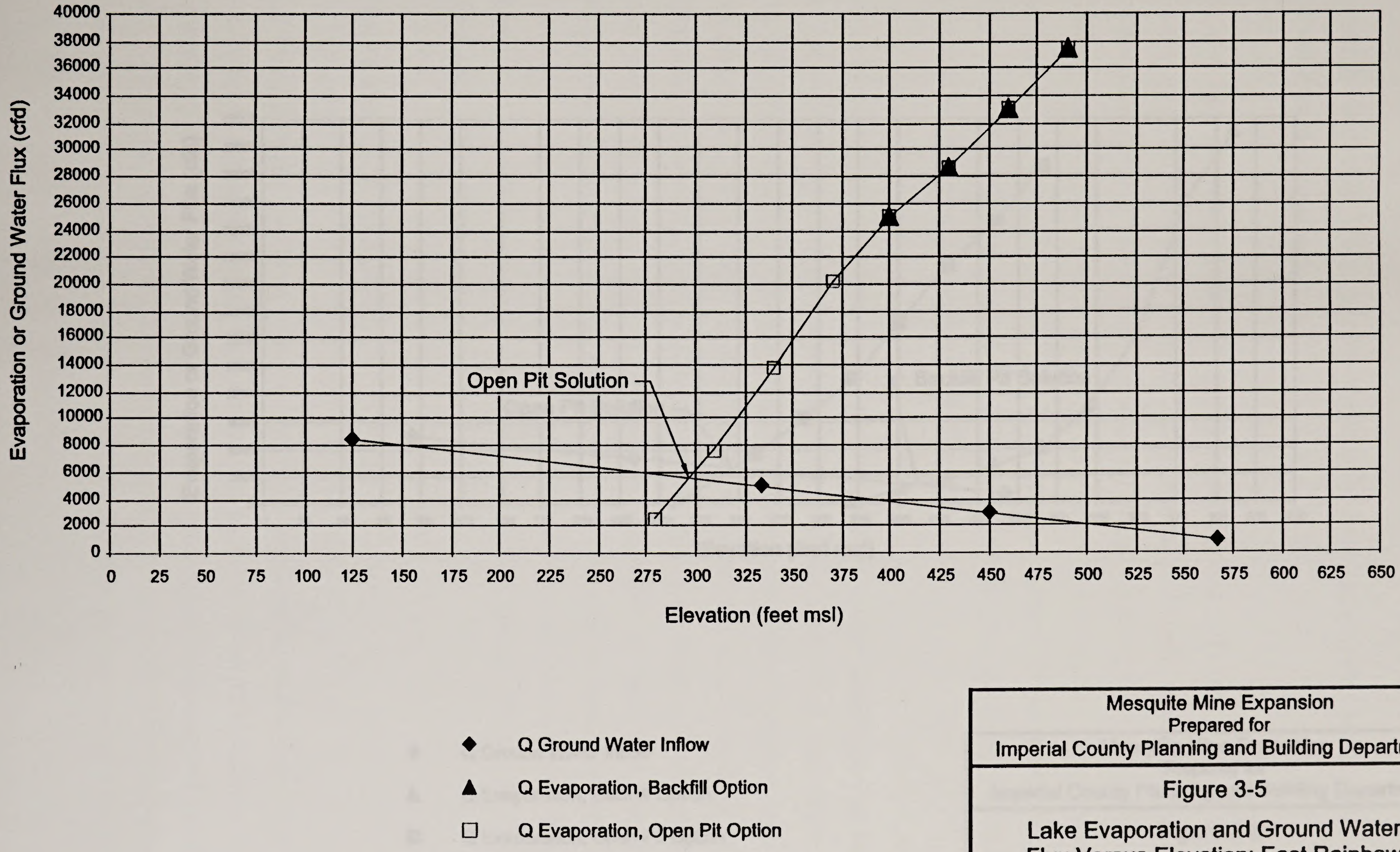

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Figure 3-5

Lake Evaporation and Ground Water Flux Versus Elevation: East Rainbow

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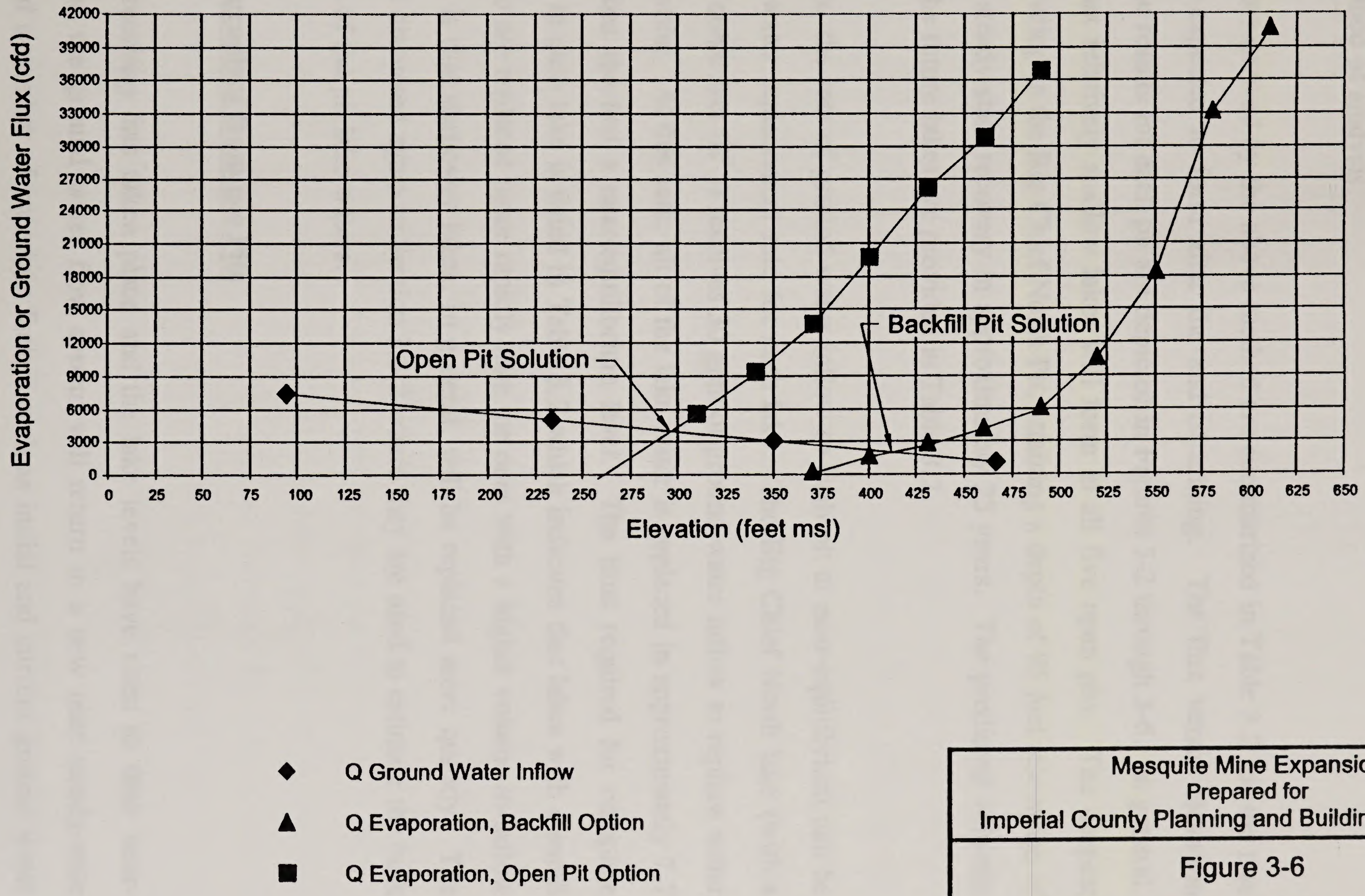

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Figure 3-6

Lake Evaporation and Ground Water Flux Versus Elevation: Vista

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BCI-fig3-6.dwg

expected to rise at equilibrium. The drawdown effects of each lake on other lakes was not considered in this method of analysis.

Final pit lake elevations derived by the above method are summarized in Table 3.2 for the five pits where lakes are expected to form after the end of mining. The flux versus elevation graphs that support the results for each pit are depicted in Figures 3-2 through 3-6. In general, the results indicate that relatively shallow lakes will form in all five open pits. The deepest lake is expected to develop in the Big Chief North Pit, attaining a depth of 95 feet (elevation of 315 feet msl) at near-steady state recovery in approximately 25 years. The predicted volumes and surface areas of the future lakes are provided in Table 3.2.

Based on these results, the rate of ground water inflow to each pit at near-equilibrium can be used to calculate the water replacement rate for each lake. The Big Chief North lake (with a volume of 16.4 x 10^6 cubic feet (ft^3)) receives 30 gpm of ground water inflow to replace water that is lost by evaporation. At this rate, all of the lake water is replaced in approximately 7.7 years after the lake has reached a near-equilibrium level. The time required for complete replacement of water in each lake is listed in Table 3.2 which indicates that lakes with a small volume-to-inflow ratio are replaced more rapidly than the ones with a higher volume-to-inflow ratio. The net result is that shallower lakes, in general, will be replaced more quickly. The replacement times are discussed again in Section 3.3.2 where they are used to estimate the bulk chemical composition of the pit lake waters.

Flow to Areas Downgradient from the Pits

After ground water recovery has taken place and the lake levels have risen to their near-equilibrium elevations, the ground water flow system will return to a new near steady-state condition. Because of a number of uncertain factors such as initial and current ground water elevations and future climatic conditions, accurate predictions of the elevation of the long-term water table and ground water gradients cannot be reliably made with the data available to this

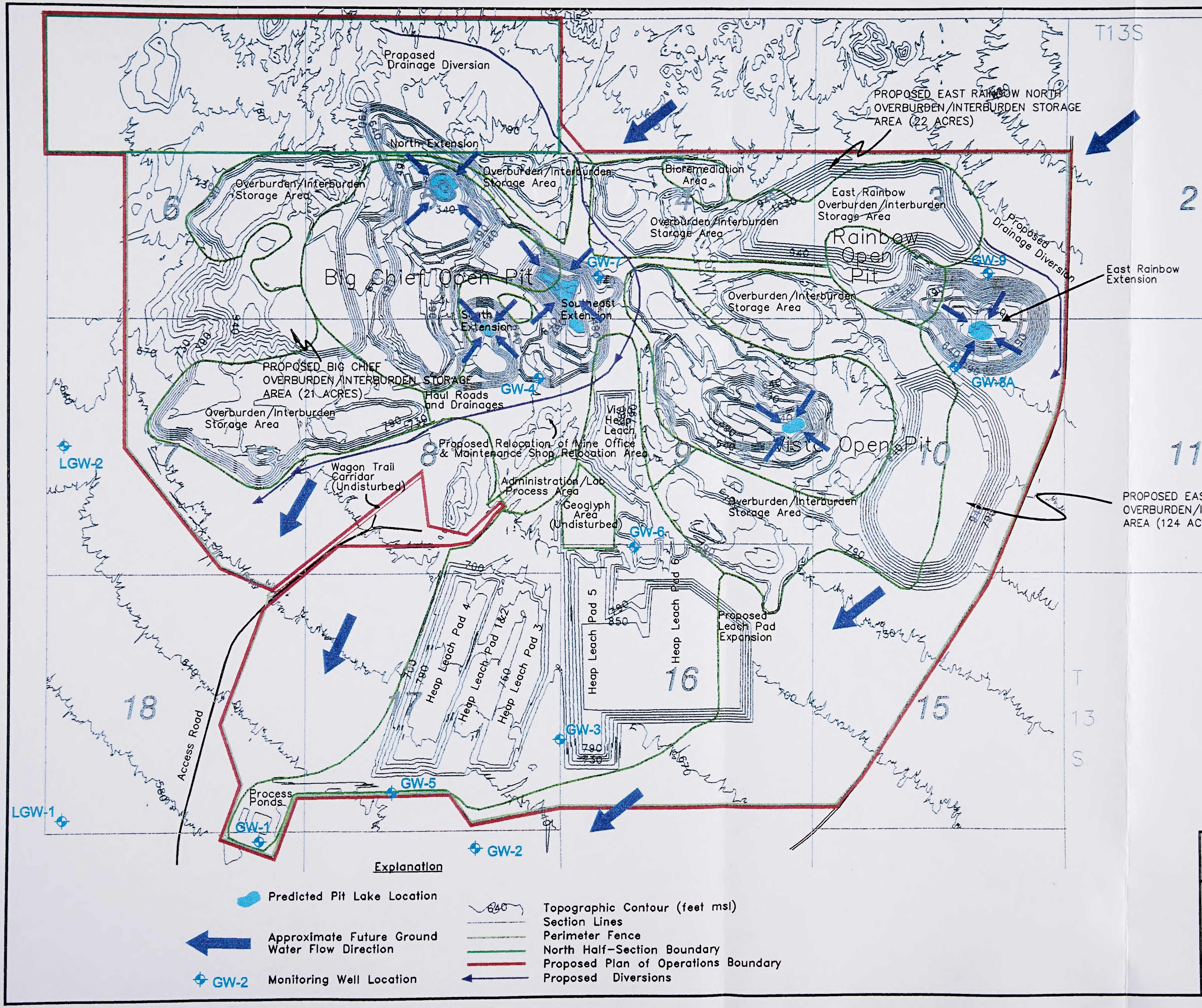
study. However, a reasonable estimate can be made of the final direction of ground water flow.

The final potentiometric surface is expected to direct ground water flow to the southwest with local drawdown occurring around each of the pit lakes (Figure 3-7). Ground water flow near the lakes will be directed inward toward each of the lakes because they are expected to act as local discharge centers, removing ground water from the system. Ground water drawdown zones are expected to enlarge because of high evaporative losses from the lake surfaces and the relatively low hydraulic conductivity of gneiss and conglomerate units in the vicinity of the pits. Inward flow toward the lakes will occur both during and after mining. The net result is that chemical constituents dissolved in ground water inflow will be delivered to the lakes where they will evapoconcentrate with time. No flow is expected to pass through the pits and continue to the southwest. As a result, no solutes are expected to be released from the pits and migrate to downgradient locations.

Uncertainty

Several factors can introduce uncertainty into the calculations discussed in the previous sections. First, there is uncertainty in the bedrock hydraulic conductivity values derived from available pumping tests. The only hydraulic conductivity measurements applicable to this study are those determined by SMI (1997) from aquifer tests performed at GW-8A and GW-9. Pit dewatering rates provided by the mine and recently-measured ground water elevations suggest that saturated hydraulic conductivities near the Rainbow and Vista Pits are consistent with those measured by SMI (1997). However, this does not appear to be the case in the vicinity of the Big Chief Pit where higher values appear to be more reasonable (Section 2.3.3).

The second factor contributing uncertainty to predictions of future hydrologic conditions around the mine pits is limited ground water elevation data. The uncertainty associated with estimates of ground water elevations in the vicinity of the mine pits under current conditions is relatively large because the only measuring points actually located adjacent to one of the pits


T13S
Prapased Drainage Diversian
North Extension
Overburden/Interburden Storage Area
Overburden/Interburden Storage Area
Bioremediation Area
Overburden/Interburden Storage Area
PROPOSED EAST RAINBOW NORTH OVERBURDEN/INTERBURDEN STORAGE AREA (22 ACRES)
East Rainbow Overburden/Interburden Storage Area
Rainbow Open Pit
Proposed Drainage Diversion
East Rainbow Extension
Big Chief Open Pit
GW-7
GW-9
South Extension
Southeast Extension
Overburden/Interburden Storage Area
PROPOSED BIG CHIEF OVERBURDEN/INTERBURDEN STORAGE AREA (21 ACRES)
Haul Roads and Drainages
GW-4
GW-8A
Overburden/Interburden Storage Area
Vista Heap Leach
Proposed Relocation of Mine Office & Maintenance Shop Relocation Area
Vista Open Pit
LGW-2
Wagon Trail Carridor (Undisturbed)
Administration/Lab Process Area
Geoglyph Area (Undisturbed)
Overburden/Interburden Storage Area
PROPOSED EAST RAINBOW SOUTH OVERBURDEN/INTERBURDEN STORAGE AREA (124 ACRES)
GW-6
Heap Leach Pad 4
Heap Leach Pad 1&2
Heap Leach Pad 3
Heap Leach Pad 5
Heap Leach Pad 6
Proposed Leach Pad Expansion
GW-3
Access Road
Process Ponds
GW-5
GW-1
LGW-1
GW-2
2
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T 13 S
N
SCALE IN FEET
1000'
0
2000'
Explanation
Predicted Pit Lake Location
Approximate Future Ground Water Flow Direction
GW-2 Monitoring Well Location
640 Topographic Contour (feet msl)
Section Lines
Perimeter Fence
North Half-Section Boundary
Proposed Plan of Operations Boundary
Proposed Diversions

Mesquite Mine Expansion
Prepared for
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Figure 3-7

Predicted Pit Lake Occurrence and Ground Water Flow Direction Open Pit Option

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BCIfig3-7

are GW-8A and GW-9 near the Rainbow Pit. There are no monitoring wells near the Big Chief Pit and, therefore, ground water elevations for this pit had to be estimated from observations of first-encountered water in exploration boreholes. The few boreholes in which first-encountered water was reported were drilled west of the pit and not directly adjacent to the pit. The result of limited data is that the uncertainty in current water level estimates for the Big Chief Pit area is significantly greater than the eastern portion of the mine site where wells are available for measurement.

Uncertainty is also high in ground water elevations predicted under pre-mining conditions. Pre-mining ground water elevations (see Section 2.3.2) were also estimated from borehole logs in which first encountered water was indicated. The uncertainty in these measurements is high because first water is usually detected several to tens of feet below true static ground water levels in reverse circulation boreholes. In addition, many of the observations of first-encountered water occurred at depths within low-permeability units in the Tertiary conglomerate or in fractured bedrock immediately below the conglomerate. Under field conditions when the driller has been adding water to the borehole above the water table, it is usually difficult to accurately detect a small inflow of ground water into the borehole. The water table is commonly noted only after inflows have been significant and noticeable.

The uncertainty in pre-mining ground water elevations has important repercussions for the pit lake and ground water recovery calculations performed as part of this study. First, pre-mining ground water elevations provide the best indication of the near-equilibrium conditions to which the ground water table will rise after mining activities have been completed. Second, pre-mining water levels estimated for each mine pit are used as the initial condition for pit dewatering and lake recovery calculations. If the pre-mining water levels are underestimated, then all recovery elevations will also be underestimated

Finally, variable and irregularly-documented pit dewatering rates contribute uncertainty to hydrologic predictions made in this study. Dewatering rates for the existing pit lakes have varied considerably over the three-year period for which records are available. The locations

and rates of pumping have been determined by operational needs as well as the need to maintain water levels in different areas of the pits. The mine pits are dewatered by a series of sumps which are pumped out to water trucks distributing water for road dust control. The number of truck loads of water distributed per day are recorded. The decision to use water from a particular sump is influenced by short-term, local, dewatering needs. As a result a single pit may be pumped intensively for several days or a month and then not pumped at all for an extended period. There are no flow meters with which to confirm the water hauling records. Over the long term, an average dewatering rate can be estimated for each pit from the water haulage records, but the level of uncertainty in the calculated dewatering rates is essentially unknown.

3.3.2 Hydrogeochemistry

The USEPA geochemical equilibrium speciation model MINTEQA2 (Allison et al., 1991) was used to simulate the near steady-state chemical composition of the five lakes predicted to develop in the Big Chief, Rainbow and Vista Pits after mining activities have ceased. MINTEQA2 is a thoroughly-documented, validated and widely-accepted geochemical code that has been applied nationally to simulate water-rock interactions in a variety of natural and synthetic waters. The chemistry of ground water flowing into the pits was represented by the geometric mean concentrations of chemical constituents detected at monitoring wells GW-3, GW-4, GW-5, GW-6, GW-8A and GW-9 during the most recent sampling round (Section 2.4.2 and Table 2.7). Water quality data from GW-1 and GW-2 were not used in the modeling effort because the chemistry monitored south of the process pond and leach pads does not appear to be representative of the chemistry of ground water inflows to the pits (Figure 2-9). Water quality data from GW-7 were not used because little is known about the construction and screened interval of this well.

The bulk chemical composition of each lake was calculated from the mass of chemical constituents delivered in ground water inflows to the pits. During the period of lake formation, ground water inflows are expected to exceed evaporative losses from the rising lake

surfaces. However, the initially high inflow rates (final pit dewatering rates) gradually decrease with time until the lakes attain near steady-state conditions when the inflow rates exactly match the lake evaporation loss rates. For estimation of the bulk chemistry of the lakes, the mean ground water inflow rates were assumed to be equal to the average of the initial and final inflow rates (Q_E). The mass of chemical constituents delivered to each lake during filling was calculated from the mass flux rates and lake filling times.

The total mass of the chemical constituents was divided by the final lake volume to determine the bulk concentration of each constituent. The bulk chemical composition of the lake waters at near steady-state was then submitted to MINTEQA2 for simulation of the major geochemical processes that are expected to control the final equilibrium chemistry of the lakes. The processes that were simulated were:

- Aqueous speciation of chemical constituents in the lake water, including computation of the concentrations of free ions, ion pairs and complexes;
- Mineral precipitation;
- Oxidation-reduction reactions;
- Equilibrium with atmospheric oxygen and carbon dioxide gases; and,
- Adsorption of trace metals in the lake water to precipitated ferric hydroxide.

The equilibrium chemistry of each pit lake was simulated in two consecutive MINTEQA2 modeling steps. The first modeling step included equilibration of the bulk water composition with atmospheric carbon dioxide ($10^{-3.5}$ atm) and oxygen (0.2 atm), mineral precipitation, and computation of the final solution pH. To maintain numerical stability and facilitate convergence of the model, only the chemical constituents that contributed to the majority of the solution charge balance were included in this model simulation (Ag, Al, As, B, Ba, Ca, Cl,

CO_3, F, Fe, K, Mg, Mn, Na, NO_3, PO_4, SiO_2, SO_4, Zn and total H). The minerals that were allowed to precipitate if they were oversaturated (positive saturation indices) were: amorphous aluminum hydroxide ($Al(OH)_3$), amorphous ferric hydroxide ($Fe(OH)_3$), barite ($BaSO_4$), fluorite (CaF_2), calcite ($CaCO_3$), gypsum ($CaSO_4.2H_2O$), manganite (MnOOH) and sepiolote ($Mg_2Si_3O_6(OH)_4$). The suite of minerals that was considered to be plausible for precipitation was based on evaluation of evaporite minerals known to precipitate in alkaline and playa lake settings, minerals simulated to be close to saturation in the surrounding ground water, and kinetic considerations.

In the second MINTEQA2 modeling step, the full suite of 30 chemical constituents was submitted for geochemical speciation and the water was again allowed to equilibrate with atmospheric oxygen and carbon dioxide. The solution pH and mass of amorphous ferric hydroxide determined in the first modeling step were applied to the second modeling step. Mineral precipitation (with the same minerals listed above) was again allowed.

The second MINTEQA2 modeling simulation also allowed the sorption of trace elements and heavy metals onto the substrate of amorphous ferric hydroxide precipitated during the first modeling step. Sorption of ions was simulated using the diffuse double layer modeling approach (Grahame, 1947; Bolt, 1979). The high-affinity site density used for the substrate was 0.005 mole sites per mole of iron and the low-affinity site density used was 0.2 mole sites per mole of iron (Dzombak and Morel, 1990). The specific surface area of the substrate was estimated to be 600 m^2/g (Dzombak and Morel, 1990). Sorption onto amorphous ferric hydroxide was considered for H^+, OH^-, As^{5+}, B, Cd^{2+}, Hg^{2+}, Ni^{2+}, Pb^{2+},Se^{6+} and Zn^{2+}. Thermodynamic data for the sorption modeling were compiled from a number of literature sources (Davis and Leckie, 1978; Davis and Leckie, 1980; Dzombak and Morel, 1990).

The predicted water quality of the Big Chief North, Big Chief South, Big Chief Southeast, Rainbow and Vista lakes under near steady-state conditions is presented in Table 3.3. The concentrations reported in the table represent the chemical composition of the lakes when they have achieved complete recovery to their final lake surface elevations. The recovery times in

each lake (listed in Table 3.2) are predicted to be 25 years for Big Chief North lake, 10 years for Big Chief South lake, 20 years for Big Chief Southeast lake, five years for Rainbow lake and 30 years for Vista lake.

The predicted chemical composition of the lake waters is generally consistent with shallow, terminal lakes exposed to moderate to severe evaporative losses in arid climates. The lakes are alkaline and moderately saline. Sodium, chloride, sulfate and carbonate are the predominant chemical constituents; magnesium, potassium, boron and fluoride are present in lesser concentrations; and calcium and other metals are minor constituents. Trace metal concentrations are generally low with the exception of antimony and selenium.

Because the lakes have no natural outlets, the predicted water quality is to a large degree determined by lake volumes and recovery times which control the salinity of the evaporating lake waters. Big Chief North, Big Chief Southeast and Vista lakes, which have comparable (same order of magnitude) lake volumes and replacement times, are predicted to attain a pH of 9.1 with TDS concentrations ranging from 5,890 to 7,280 mg/L (Table 3.3). The smallest lake, Big Chief South lake, is also predicted to be the most saline, attaining a pH of 9.2 and TDS concentration of 11,400 mg/L. East Rainbow lake which is approximately twice the volume of Big Chief South and fills the fastest of all the lakes, has the lowest pH (9.0) and concentration of TDS (5,180 mg/L). As evapoconcentration continues, the concentrations of solutes in the lakes are expected to increase.

The chemical concentrations of several chemical constituents listed in Table 3.3 are predicted to exceed California water quality goals. Concentrations of antimony, fluoride and selenium exceed primary MCLs; chloride, sulfate and TDS exceed secondary MCLs; and aluminum, boron, and selenium exceed ambient aquatic or irrigation water quality goals.

TABLE 3.1 MINE PIT ELEVATIONS AND DEWATERING ESTIMATES

Pit Name	Final Pit Floor Elevation (ft msl)	Estimated Maximum Dewatering Rate Required (gpm)[1]
Big Chief North	220	100
Big Chief South	430	35
Big Chief Southeast	280	65
East Rainbow	280	65
Vista[2]	220[3]	55

[1] Assumes that dewatering will be accomplished primarily via sumps.

[2] Dewatered and mined under existing permits during 1999 and 2000. Included here because it is an activity that will affect final ground water recovery under both options considered.

[3] Maximum depth of the pit will reach 220 feet msl but 90 feet of waste rock may be backfilled into the pit to raise floor to 310 feet msl upon completion.

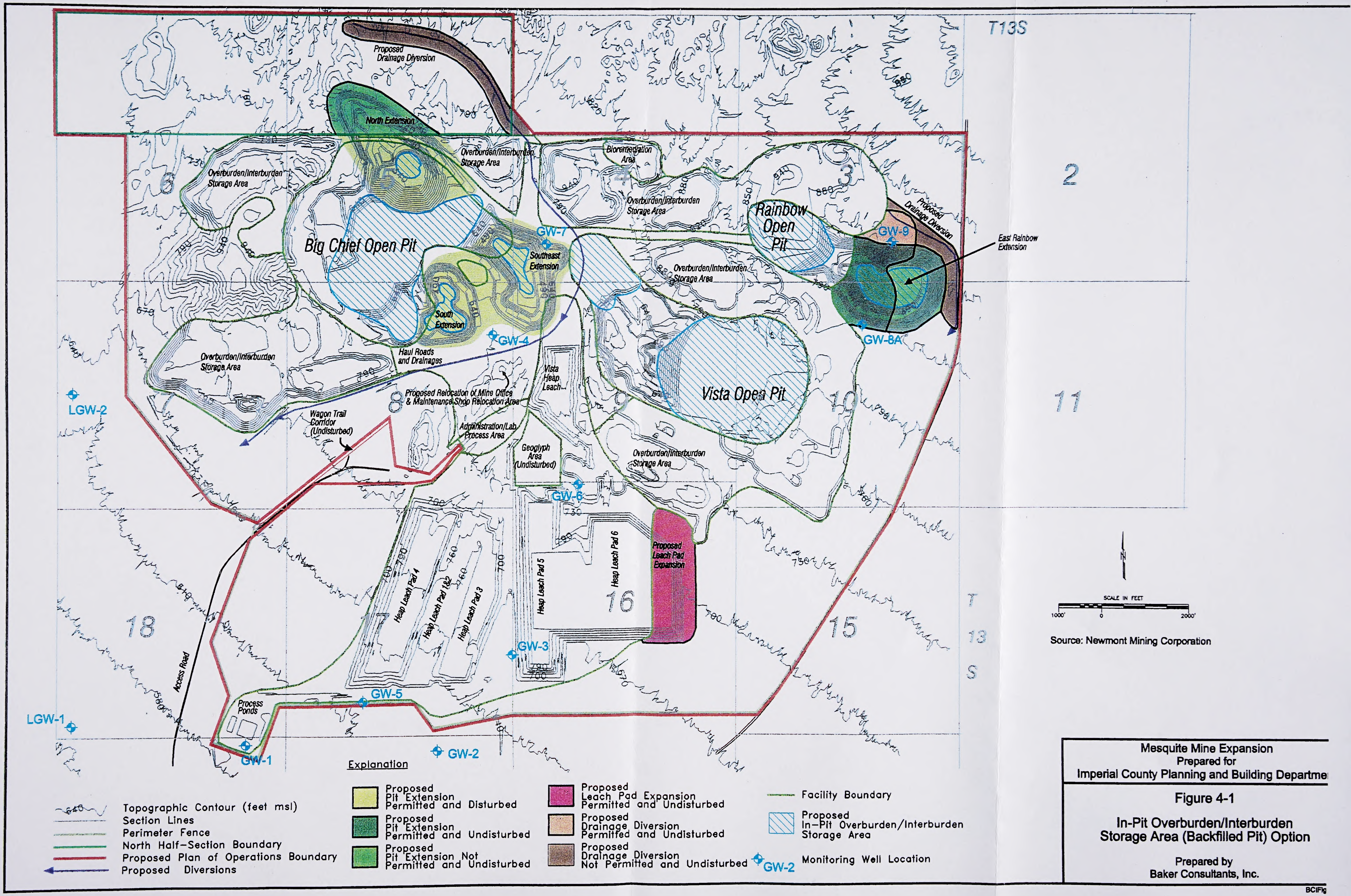
TABLE 3.2 POST-MINING PIT LAKE CONDITIONS: OPEN PIT OPTION

Pit Name	Final Pit Floor Elevation (ft msl)	Final Pit Lake Elevation/ Depth (ft msl)/(ft)	Final Ground Water Elevation/ Depth in Backfill (ft msl)/(ft)	Final Lake Area (ft^2)/(Acres)	Final Lake Volume (ft^3)	Final Ground Water Inflow Rate (gpm)	Recovery Time to Final Elevations (yrs)	Lake Replacement Time (yrs)
Big Chief North	220	315/95	NA/0	330,000/7.6	16.4 x10^6	30	25	7.7
Big Chief South	400	415/15	NA/0	169,000/3.9	1.6 x 10^6	15	10	1.5
Big Chief Southeast	280	350/70	NA/0	295,000/6.8	10.8 x 10^6	30	20	5.1
East Rainbow	280	295/15	NA/0	320,000/7.3	3.4 x 10^6	30	5	1.6
Vista	220	295/75	295/75	220,000/5.0	14.1 x 10^6	20	30	10.0

TABLE 3.3 PREDICTED LAKE WATER QUALITY: OPEN PIT OPTION

Parameter	Concentration (mg/L except pH which is in standard units)				
	Big Chief North (25 years)	Big Chief South (10 years)	Big Chief Southeast (20 years)	East Rainbow (5 years)	Vista (30 years)
Aluminum	0.124	0.196	0.110	0.087	0.100
Ammonia (as N)	0.035	0.056	0.031	0.025	0.028
Antimony	0.011	0.017	0.009	0.007	< 0.002
Arsenic	<0.002	<0.002	<0.002	<0.002	<0.002
Barium	0.007	0.006	0.007	0.008	0.007
Boron	8.01	12.82	7.08	5.59	6.41
Cadmium	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Calcium	1.80	1.42	1.93	2.21	2.05
Chloride	1,851	2,933	1,641	1,301	1,488
Chromium	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Copper	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Fluoride	12.5	19.8	11.1	8.8	10.0
Iron	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Lead	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Magnesium	21.1	27.3	20.1	18.6	19.4
Manganese	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Mercury	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	< 0.023	< 0.023	< 0.023	< 0.023	< 0.023
Nitrate/Nitrite (as N)	2.21	3.50	1.96	1.55	1.77
pH	9.12	9.22	9.09	9.04	9.07
Phosphate (as P)	0.302	0.479	0.268	0.213	0.243
Potassium	33.3	52.7	29.5	23.4	26.7
Selenium	0.049	0.079	0.044	0.035	0.040
Silica	26.8	19.9	28.9	32.8	30.5
Silver	0.020	0.031	0.018	0.014	0.016
Sodium	2,538	4,023	2,252	1,786	2,041
Sulfate	2,187	3,466	1,940	1,538	1,758
TDS[1]	7,280	11,400	6,480	5,180	5,890
Total Inorganic Carbon (as CO_3)	589	847	536	450	497
Zinc	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007

[1] Calculated by summation of major cations and anions


T13S
Proposed Drainage Diversion
North Extension
Overburden/Interburden Storage Area
Bioremediation Area
2
6
5
4
3
Overburden/Interburden Storage Area
Overburden/Interburden Storage Area
Rainbow Open Pit
Proposed Drainage Diversion
GW-9
GW-7
East Rainbow Extension
Big Chief Open Pit
Southeast Extension
Overburden/Interburden Storage Area
South Extension
GW-4
GW-8A
Haul Roads and Drainages
Overburden/Interburden Storage Area
Vista Heap Leach
Vista Open Pit
11
LGW-2
7
8
9
10
Proposed Relocation of Mine Office & Maintenance Shop Relocation Area
Wagon Trail Corridor (Undisturbed)
Administration/Lab Process Area
Geoglyph Area (Undisturbed)
Overburden/Interburden Storage Area
GW-6
Heap Leach Pad 6
Proposed Leach Pad Expansion
Heap Leach Pad 5
16
Heap Leach Pad 4
Heap Leach Pad 1&2
Heap Leach Pad 3
17
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T 13 S
Access Road
GW-3
GW-5
Process Ponds
LGW-1
GW-1
GW-2
N
SCALE IN FEET
1000'
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2000'
Source: Newmont Mining Corporation
Explanation
640 Topographic Contour (feet msl)
Section Lines
Perimeter Fence
North Half–Section Boundary
Proposed Plan of Operations Boundary
Proposed Diversions
Proposed Pit Extension Permitted and Disturbed
Proposed Pit Extension Permitted and Undisturbed
Proposed Pit Extension Not Permitted and Undisturbed
Proposed Leach Pad Expansion Permitted and Undisturbed
Proposed Drainage Diversion Permitted and Undisturbed
Proposed Drainage Diversion Not Permitted and Undisturbed
Facility Boundary
Proposed In–Pit Overburden/Interburden Storage Area
GW-2 Monitoring Well Location

Mesquite Mine Expansion
Prepared for
Imperial County Planning and Building Departme

Figure 4-1

In-Pit Overburden/Interburden Storage Area (Backfilled Pit) Option

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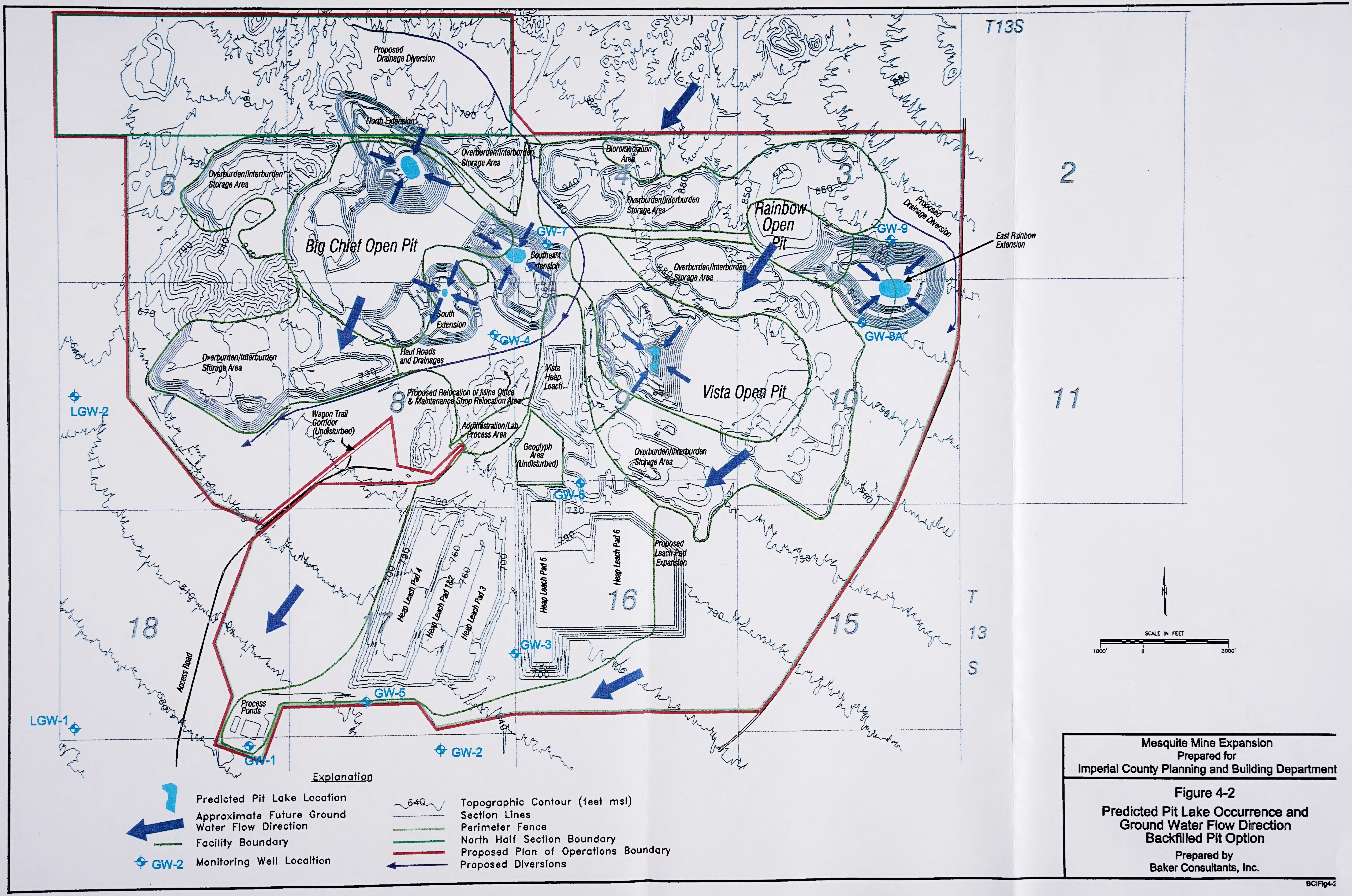
BCIFig


T13S
Proposed Drainage Diversion
North Extension
Overburden/Interburden Storage Area
Bioremediation Area
Rainbow Open Pit
Proposed Drainage Diversion
East Rainbow Extension
GW-9
GW-7
Southeast Extension
Big Chief Open Pit
South Extension
GW-4
GW-8A
Haul Roads and Drainages
Vista Heap Leach
Vista Open Pit
Proposed Relocation of Mine Office & Maintenance Shop Relocation Area
Wagon Trail Corridor (Undisturbed)
Administration/Lab Process Area
Geoglyph Area (Undisturbed)
GW-6
LGW-2
Heap Leach Pad 4
Heap Leach Pad 1&2
Heap Leach Pad 3
Heap Leach Pad 5
Heap Leach Pad 6
Proposed Leach Pad Expansion
GW-3
GW-5
Access Road
Process Ponds
LGW-1
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SCALE IN FEET
1000'
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2000'
Explanation
Predicted Pit Lake Location
Approximate Future Ground Water Flow Direction
Facility Boundary
GW-2 Monitoring Well Location
640 Topographic Contour (feet msl)
Section Lines
Perimeter Fence
North Half Section Boundary
Proposed Plan of Operations Boundary
Proposed Diversions

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Prepared for
Imperial County Planning and Building Department

Figure 4-2
Predicted Pit Lake Occurrence and Ground Water Flow Direction Backfilled Pit Option

Prepared by
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BCIFig4-2

5.0
SUMMARY AND CONCLUSIONS

Open Pit Option

1) The Big Chief North Pit will form a pit lake approximately 7.6 acres in area and 95 feet deep over a period of 25 years. The lake will be alkaline with a pH of approximately 9.1 and TDS concentration of 7,230 mg/L.

2) The Big Chief South Pit will form a pit lake within approximately 10 years that is 15 feet deep at its predicted maximum level. The lake water will be a sodium sulfate, chloride-rich mixture with a pH of approximately 9.2 and TDS concentration of about 11,400 mg/L.

3) The Big Chief Southeast Pit lake will attain a maximum depth of approximately 70 feet in approximately 20 years. Lake water quality will be similar to that of the south pit lake with pH and TDS values of approximately 9.1 and 6,480 mg/L, respectively.

4) The East Rainbow Pit is expected to reach its highest level in about five years, covering 7.3 acres and reaching a depth of 15 feet. Values of pH and TDS at that time are expected to be approximately 9.0 and 5,180 mg/L.

5) The lake that develops in the Vista Pit is expected to reach its maximum depth of 75 feet in approximately 30 years. Lake water quality is expected to be alkaline with sodium, sulfate, chloride as the major chemical constituents. The lake pH and TDS concentration are expected to be 9.1 and 5,890 mg/L, respectively.

6) No lake is expected to form in the main body of the Big Chief Pit.

7) Due to the relatively high evaporation losses and corresponding ground water inflow rates, no pit lake water is expected to leave the pits that contain lakes and migrate into surrounding ground water.

8) Under the open pit option, the lake waters will contain elevated concentrations of aluminum, antimony, boron, chloride, fluoride, selenium, sulfate and TDS.

Backfilled Pit Option

9) The Big Chief North Pit will form a pit lake of approximately 8.2 acres in area and 15 feet deep over a period of 35 years. At that time, the water quality of the lake will be alkaline with a pH of approximately 9.2 and concentration of TDS of nearly 7,890 mg/L.

10) The Big Chief South Pit will form a pit lake within approximately 105 years that is 1.3 acres in area and five feet deep at its predicted maximum elevation. The chemical composition of the lake will be predominantly a mixture of sodium chloride and sulfate with a pH of approximately 9.2 and TDS of about 58,000 mg/L.

11) The Big Chief Southeast Pit lake will attain an area of 4.9 acres and a maximum depth of approximately five feet in approximately 50 years. Lake water quality will be similar to that of the north pit lake. The lake will have a pH and TDS concentration of approximately 9.4 and 14,700 mg/L, respectively.

12) The East Rainbow Pit lake is expected to reach its highest level in about 50 years, covering five acres and extending to a depth of five feet. Values of pH and TDS at that time are expected to be approximately 9.4 and 14,700 mg/L, respectively.

13) A lake is expected to develop and reach its maximum depth of 45 feet in the Vista Pit in approximately 100 years. Lake water quality is expected to be alkaline with an overall chemical composition resembling sodium sulfate/chloride. The pH of the lake is expected to be 9.4 and TDS concentration is expected to reach 17,900 mg/L.

14) Lakes that develop under the backfilled pit option are expected to contain elevated concentrations of aluminum, antimony, boron, chloride, fluoride, selenium, sulfate and TDS. The Big Chief South pit lake will be strongly saline, contain elevated levels of the above constituents, and in addition, will have high concentrations of silver, and nitrate/nitrite.

15) Under the backfilled pit option, ground water quality downgradient from the Big Chief South Pit is expected to be influenced by pit lake water and pit backfill leachate. All other lakes are expected to create inward flow to the lake preventing ground water effects. Ground water passing through the backfilled Rainbow Pit and the east end of Vista Pit will be influenced by the backfill.

General Conclusions

16) There is a significant difference in hydrogeologic conditions in the Big Chief area, compared to the eastern portion of the mine site. Aquifer hydraulic conductivity near the Big Chief Pit is believed to be significantly higher than that measured near the Rainbow Pit. All calculations and estimates of future lake levels, filling times and chemical concentration rates for the three Big Chief pit lakes contain greater uncertainty than those for the East Rainbow and Vista pit lakes.

17) The chemistry of waste rock leachate is based on two rock samples from a single borehole drilled in the Rainbow Pit. Consequently, the uncertainty about the chemical composition of water that passes through waste rock in the East Rainbow and Vista Pits

is moderate because it is unknown whether the samples submitted for kinetic testing are truly representative of bedrock in these pits. The kinetic test results for the two samples are not representative of materials in the Big Chief North area, as indicated by ABA and whole rock analyses of samples from the North Half-Sections. Therefore, there is considerable uncertainty in the prediction of pit lake water quality in the Big Chief Pit under the backfilled pit option, compared to predictions provided for lake water quality in the backfilled Rainbow and Vista Pits.

18) Ground water resources around the mine site will be affected under both options because of a continuous loss of water from the aquifer due to pit lake evaporation. Ground water quality should not be significantly affected under the open pit option due to the formation of the pit lakes. Under the backfilled pit option, some ground water will pass through backfilled waste rock and be influenced by additional chemical loading from the backfill.

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